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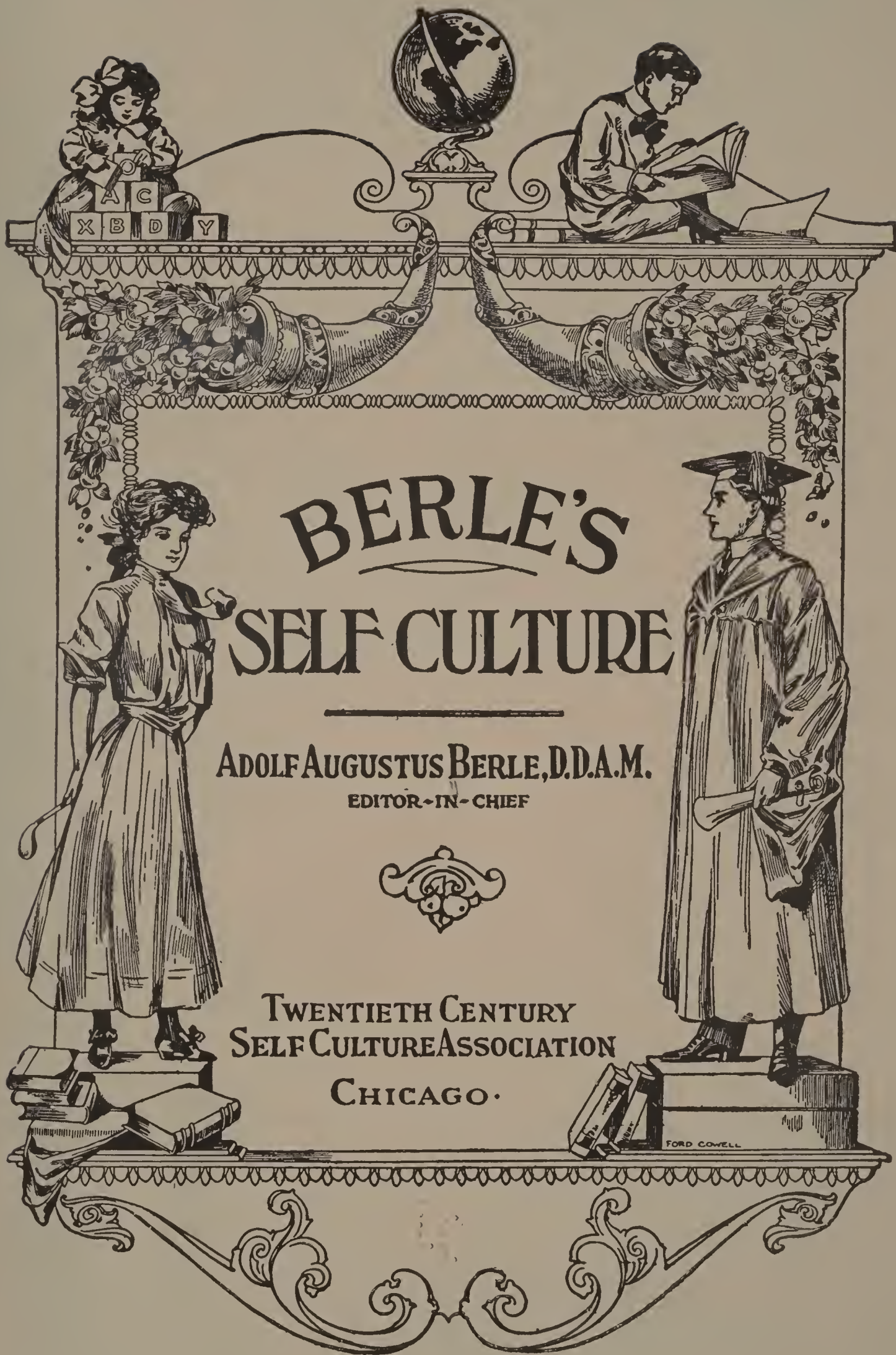


FROM THE PAINTING IN
THE LOUVRE BY
LEOPOLD LOUIS ROBERT

NOW the wit doth flow
Till the wine is out;
Then with song and shout
Home they go, yo ho!"

LUDWIG H. C. HÖLTY

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BERLE'S SELF CULTURE

ADOLF AUGUSTUS BERLE, D.D.A.M.
EDITOR-IN-CHIEF

TWENTIETH CENTURY
SELF CULTURE ASSOCIATION
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BERLE'S
SELF CULTURE

VOL. VII

OUR WONDERFUL WORLD

BERLE'S SELF CULTURE

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INTRODUCTION

OUR WONDERFUL WORLD

BY

BENJAMIN IDE WHEELER, LL. D.,

President, 1899-1919, The University of California

PITY for the man who has no delight in wonders! He who has not begun to wonder is the carnal savage; he who has ceased is the cynic. Human culture began with the passing of fear into wonder, and today it turns toward degenerate death in the sneer at honest enthusiasm.

No matter how firm our intellectual conviction that the laws of nature operate in total sweep and perfect uniformity, there is always room for the miracle. Electricity remains, after all the control that knowledge of its habits has established, still a source of mystery to the engineer, and radio-activity is just beginning to work its miracles before the eyes of the physicist. The genuine man of science is the man who more and more wonders. Instead of forcing upon nature his knowledge or his preconception, he persists in his experiments; that is, he persists in asking Nature questions, and heeds her answers. It is the fool who hath said in his heart, "I am not surprised."

The Grand Cañon of the Colorado is a colossal exhibit in geology, but it is not geology that makes the Cañon great. Science is not the one official guide to wonder in the things of nature; wonder is the protoplasm out of which science grows. The Cañon is great, because it doth greatly teach and move the various sons of men according to their various knowledges and needs. It brings the shock of new perspective in the life of man upon the globe, in the life of man with men; it strikes new balance among the things worth while; it courts new visions and other doings; it breaks the ruts, and beckons out. This is what the world's wonders have always been doing, ever since wonder rose above fear.

Long before the mountains and the seas had ceased to be girt with dread, the mighty works of men had become the objects of wonder; indeed, it was in the main only by transferring the analogy of man's great works to the majesties of nature and discerning therein the control and purpose of men writ large to gods and demigods,

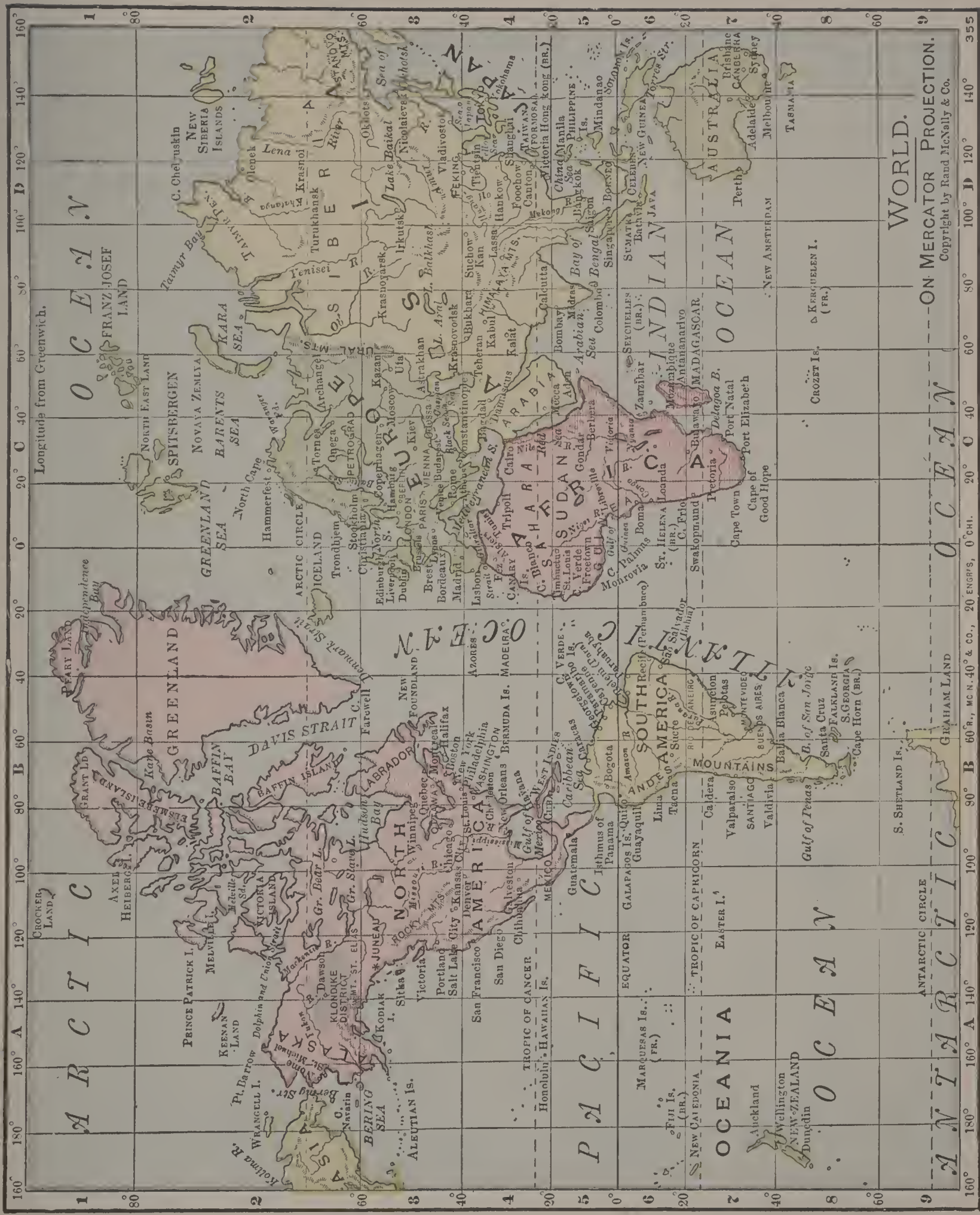
OUR WONDERFUL WORLD

that nature was brought near enough to be familiar and so to emerge from the domain of fear into that of wonder. And even to-day the commonest device of human wonder at the works of nature sees domes and pinnacles in the mountains, and pillars and buttresses in the cliffs. The childhood of the race is still in our blood, and we turn aside, perhaps journey miles, to view some giant profile against the mountain side, reluctant to believe that some intelligence akin to ours had not designed it.

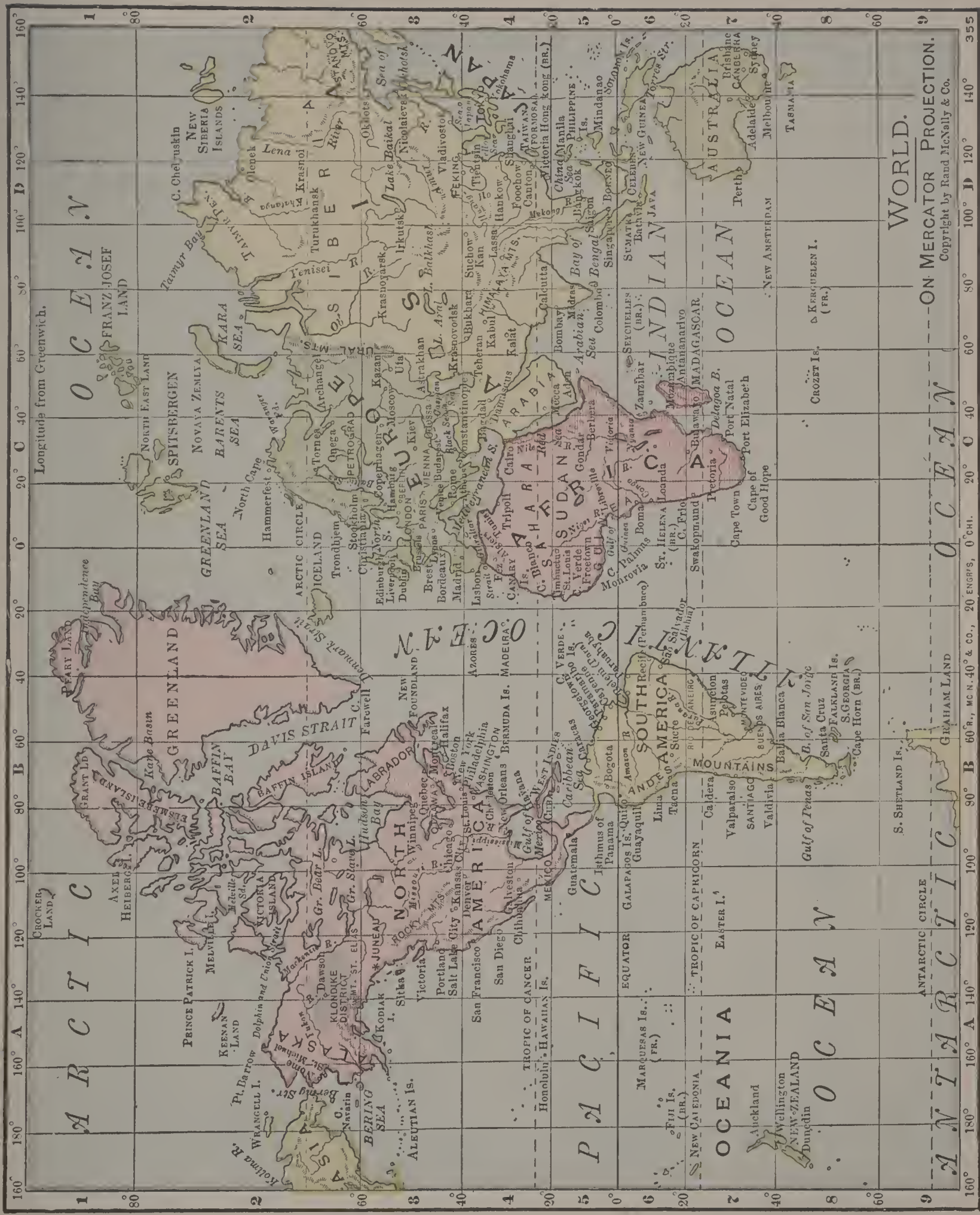
Reason says it is an accident, a freak of nature, but deeper than reason is a feeling that gives the freak its charm, and therewith is nature-worship, which we had banished to the ancients, present with us in life and vigor still.

Near akin hereto is therefore the wonder of the Parthenon and the Pyramids, of the Colossus and the hanging gardens. Surely they were built by men of greater wisdom and strength than those of today,—so speaks the wondering child within us; surely there was a virtue in the past higher than that of the present; surely there was a silver and a golden age before the age of iron and steel. All this is part and parcel of the old-time, age-long doctrine of heroes and the heroic, always seeking the foundations of states and of goodly usage, the standards of the art and wisdom and the sources of authority for faith somewhere in a nobler, statelier past.

It is all the wonder of children, but the wonder calls as to the ear of the child Samuel through the dark of the temple. The great that is about us calls to the great that is within us, and bids us be worthy.



WORLD.
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OUR WONDERFUL WORLD

THE BEGINNING OF THE EARTH.

BY

A. W. BICKERTON,

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WONDERFUL are the changes brought about by the many motions of the flying earth! How complex they are! Our planet rotates on its axis, which causes day and night. It revolves in its orbit, in a leaning position, which produces the seasons. The pull of the moon and sun on the leaning top causes the axis to rotate conically, and this motion it completes in about 26,000 years, the motion being styled the precession of the equinoxes. The pull of the moon makes it sway backward and forward in its orbit; and this pull has to do with the tides. The pull of the other planets alters the eccentricity of its revolution, so that the sun is sometimes much farther from the centre of its orbit than at present; and this variability, combined with the conical motion, causes rhythms of arctic and tropical climate, called glacial periods, which have produced extraordinary changes in the history of living creatures upon the earth.

Turning from these great changes to contemplate the earth's surface, we see a tumult of life, of struggle and conquest, of birth, maturity, and death, of organisms and their parasites, and the parasites of parasites. The microscope shows the seemingly inert soil of the field to be teeming and seething with the most varied life; it exhibits a drop of stagnant water as a world of wonders. The

From "The Romance of the Earth," London.

profusion of variety and the complexity of detail seem at first to have no limit. Among insects alone the different kinds or species are numbered by hundreds of thousands. Nor is there only variety due to place, but also variety due to time. Go back a tick of eternity's pendulum, and the life clothing the earth is altogether unlike its present vesture. There are no marks of man's hand upon the earth, for man does not exist. Another tick—the flowering-plants and the mammals are not on the scene; huge reptiles swarm amid the forests of clubmosses, ferns, and horsetails. Still another tick—the sunlight has not begun to use the green coloring matter called chlorophyll to split carbonic acid asunder, and thus there is no vegetation at all. Further back the earth is a great red-hot cinder; further again, a molten ball surrounded by a dense, flaming, gaseous atmosphere.

Now, let us skip a few millions years and consider the earth as a member of one of the parent systems from which, by impact, our own solar system originated. Perchance many planets belonged to that old-time system. Almost certainly they did not revolve in a plane, but moved at all angles and in all directions; in an order beautiful enough of its kind, but not the order of our present system. Imagine an old-time astronomer watching from the then earth the erratic movements of another planet! He is startled by its being out of place; some unknown sister would, perhaps, account for this; but the variation is too sudden and too great. Is it a dead sun, or a small, burnt-out star cluster that draws near? He tells his fellow-observers, and presently every one is at work. By the movements of all the planets it becomes certain that another orb is coming. Will it collide with the earth—with some other planet—may it graze the sun? Presently some of the stars are eclipsed by the dark body. Now, with reflected solar light, it begins to glow, as a distant planet. Now, its orbit can be figured out. It will graze the sun! It will be nearly a half graze. A new sun will be born—a fiery nebula produced that will envelop the earth. The old order is over, and, as a sum is sponged from a slate, so life is swept from the globe.

What was the nature of the two colliding bodies that gave birth to our solar system? Our imaginary astronomer can give us no information; we can only conjecture. For possibly no cosmic problem offers so fertile a field of inquiry as the impact of celestial bodies. If the paper in the *Philosophical Magazine* on Cosmic Evolution represents the truth, as a vast mass of evidence seems to show it does, then impact is the Promethean spark that gives life to decaying worlds and systems. The idea of an impact that is a mere graze is that a brilliant spark has been produced by the colliding part of the dead suns as they swept past each other. Such is probably the phenomenon that produces the new stars that occasionally burst forth suddenly with great splendor. But the new star is too hot to be stable; each molecule may have velocity enough to carry it entirely away into space to help in the formation of new and distant universes. The brilliant, flaming mass expands first into a hollow shell of gas called a planetary nebula, and then dissipates altogether. Nova Aurigæ was the first temporary star whose triple constitution was demonstrated. When instead of a mere graze the bodies plunge deeply into one another, then they join and whirl around one another; and it is to such a whirling collision, it is suggested, that the solar system owes its genesis. Let us imagine the stupendous flash of the grazing collision to have passed; the planets have been swung by centrifugal force into a plane—as a twirled mop disperses its drops of water, or a Catherine wheel its sparks of fire. The planetary bodies fly in curves almost directly from the centre, but the pull of the central mass slowly stops them, just as the pull of the earth stops the upward motion of the ball thrown in triumph at a cricket match. Then they recurve towards the denser portions of the nebula. But countless agencies are at work to alter the curves of their orbits. Let us try to understand one of these.

Suppose a cup and ball with an elastic cord. You throw the ball, and the pull of the cord brings it back. Now you throw so hard that the cord breaks; the ball does not come back, the attraction is gone. Suppose you

throw a cricket-ball upward. Imagine the earth suddenly to disappear—the ball will not return; it will travel straight on in space. Now think of our earth: it was swung off; it has curved over; it is returning. But suppose the nebula has expanded so much as to be largely outside the earth's orbit; the part outside will not be pulling it back. If half were outside, the earth would not tend to return; it would revolve in a circle; hence the planets' highly elliptical orbits became approximate circles, and so, by this agency and by many others, the order of the solar system grew up. Our earth is an inner planet. In plunging into the fiery gaseous mass, it loses its light gas and picks up heavy molecules, and, so loaded, it cannot run away. It is a heavy gaseous body, revolving in a nebula. It picks up endless smaller bodies; presently a larger mass plunges through it and gets entrapped—the earth has caught its moon.

As the solar nebula shrinks it leaves the earth outside, and the earth in its revolution in the surface of the nebula picks up its water and its atmosphere. In the earth's daytime the flaming sun covers its entire sky. Still the nebula shrinks, until Venus emerges. Now the sun is a fire covering the whole area within the orbit of Venus. Another æon, and Mercury emerges.

But, while the sun is shrinking, wonderful changes are occurring in the earth itself. The gaseous mass has become liquid, and the liquid cools on the surface and sinks, while the hotter molten material rises up from below to take its place. A circulation is thus set up that tends to cool the liquid rock to its limits. Some of the rock gradually begins to solidify on the surface and to sink. For rock is the reverse of water; water solidifies, expands, and floats; rock matter solidifies, contracts, and sinks. The molecules in the lovely ice crystals are not packed tight like bricks in a box—the crystals are structures to some extent hollow. Pressure tends to fill the spaces, to crush the crystals; in other words, to make the ice into water. But rock, when it solidifies, contracts; so, when the molecules are rigidly locked into the solid state, pressure tends to keep it solid.

As the rock sinks it is subject to pressure, and may remain solid; but it is also subject to intense heat, and may become more or less soft or plastic, or it may melt in such fervid temperature. The centre of the earth is probably composed of dense metals, like gold, platinum, lead, and mercury. Their density would limit the sinking tendency, so that the crystals of rock would float on the surface of the molten metal and gradually silt up the lava ocean, in places reaching to the surface. The space between the crystals would still be filled with molten matter, and—when the silting reached the surface—this would also begin to solidify. This silting up would be very uneven, and molten lakes would be left which would afterwards cool, solidify, and shrink, producing vast hollows—perchance our present ocean beds. Eventually the crusts would join and coat the earth with a continuous white-hot shell.

In the far back epoch we are thinking of, the carbon of the planet is probably not yet in a solid state. It is possibly all combined with oxygen as carbonic acid gas. The base of the limestone rock is still caustic, not carbonate, the date of the coal measures is still in the distant future. Some of the earth's salts and most of its chlorides are in a state of vapor, gradually condensing on the poles and other cooler parts; falling here and there as molten saline rain, and flowing as glowing lava streams into molten lakes to be boiled off again. Possibly showers of meteorites contribute towards inequalities of temperature. By-and-by, the salt is solidified, and water begins to fall as rain on the poles and other cooler regions, forming boiling lakes; some parts are still too hot for this, and the raindrops fall, to dance up again as quivering spheres buoyed up on their own steam. To boil water requires heat; thus the boiling arctic and antarctic seas cool the poles, and thus the rocks shrink and become denser, tending to sink under the increasing weight. As the water stands where the molten saline lakes solidified, it dissolves the saline matter, and the sea becomes salt.

THE MAKING OF THE EARTH'S CRUST.

Though it is by no means easy, it is worth trying to gain a living picture of the way in which the surface of the earth came to be what it is. First, the crust cools, shrinks, gets too tight, and splits; then the cool crust becomes too big for the contracting interior, so that it crumples up and breaks. All the while steam explodes, and torrents of boiling water, bearing *débris*, rush in tumult over the surface. Then, owing to the great world-changes already spoken of, ice accumulates alternately upon either pole and pushes forward upon the polar hemisphere; consequently the centre of gravity of the earth is altered, and the water is dragged to the icy hemisphere, while the opposite hemisphere is left almost dry land, with an equably temperate climate. After a long time, vegetation begins to clothe the surface, modifying all the other agencies. Evidently, while considering such a conflict of forces, we need patience as we try to thread our way through the labyrinth, with its many tortuous twists.

Although, in comparatively early epochs, the poles of the earth would, doubtless, be slightly cooler than the other parts, we must remember how water and carbonic acid oppose the penetrating power of the sun's radiant heat, so that the equator would not be much hotter than the poles. Think of all the water of seas and lakes, and all that is now contained in plants and animals, and in crystals—think of all this water existing as steam in the atmosphere along with the enormous quantities of carbonic acid not yet absorbed or decomposed! An atmosphere surpassing our own many hundred times! The sunlight would scarcely penetrate such dense clouds as the upper regions of that atmosphere would present; and, even if it did penetrate, it would be “refracted” or curved round the poles, so that polar cold would not be an important factor in producing condensation. Pressure alters the temperature of boiling water; in a perfect vacuum ice-cold water will boil; so that imagine the high temperature of the steam and rain under the pressure of an atmosphere many hundred times greater than ours

now is—equalling tons to the square inch! All these agencies would tend to produce a general equality of temperature, yet minor irregularities would appear, and in the cooler places the raindrops would spread over the surface, and the water would flow as boiling streams, combining into torrents—possessing the great dissolving power of boiling water at high pressure—bearing rocks, silt, and *débris* of all kinds. Nor must we forget that to boil water requires much heat (we know how it cools red-hot iron); hence, where the boiling water stood its cooling influence would contract the crust and tend to flatten its curve, that is, to bulge in the earth's surface, thereby forming deep depressions, wherein still more water with sedimentary and dissolved material would gather. When a mass is above what is called the "spheroidal point" it takes a long time for water to cool it—the steam keeps the water out of contact. In my boyhood, I saw a huge mass of white-hot iron being carried up the railway on a trolley crane. I followed and saw the men stop at a bridge and lower the mass into the river. There, beneath the water, hung the glowing iron. The surface of the river became a maelstrom; it boiled and bubbled, and at times the water seemed to burst away from the iron. The noise was most remarkable, yet, amidst it all, the block continued to glow. It became tedious to watch its light. The men moved the trolley backward and forward, yet still the mass glowed and grumbled. Then, after an hour or so, it began to blacken and hiss; and so it gradually cooled till it was fit to be handled.

Besides local changes, the whole crust of the earth was cooling and contracting, causing extreme strain and exerting a tremendous pressure upon the interior, so that immense splits would occur. Clearly these splits did not take place in the thick crust underlying the water areas; they occurred in the thinner crust of the dry areas, and vast ridges of molten rock poured out and out—for the contents of these splits would remain softer than the rest of the crust, and would be, as it were, safety valves allowing escape of molten rock matter. This would go

on until the superincumbent mass was so immense that its tremendous weight depressed the white-hot dry crust, which would sink below the level of the lakes, bulging their floors up and causing the water to overflow into the hot areas immediately alongside the great volcanic ridges. Again came the boiling and cooling, again the density of the crust increased; and, as time went on, this alternate action would extend over larger and larger areas. The lakes would become seas, and the seas oceans. The smaller areas of dry land would enlarge to continents, and the continents would sink until the continental areas were oceans and the oceans dry land. Imagine the effect upon the atmosphere when the waters of the ocean rushed in about a white-hot volcanic ridge, thousands of miles long; pouring into the innumerable fissures, becoming high pressure steam, exploding and throwing the rocks scores of miles high! From the whole ridge would rise an uprush of steam and air. This would be affected by the earth's rotation just as our trade winds are now affected by it, only in a tremendously exaggerated way. Awful tornadoes would occur, and the rainfall would be altogether beyond our conception.

I have seen a storm in the Otira Gorge in New Zealand; but what was that to the possibilities in the early volcanic period of the earth's history! The rainfall of such storms would be estimable, not in inches, but in hundreds of feet. Yet a few inches produce effects almost incredible. In the Otira storm the rain seemed to fall in sheets. Immense cascades began to gush from the mountain sides where no sign of even a rivulet had appeared before. From higher and still higher points the cascades started forth, shooting out of the dense forest thousands of feet aloft, leaping over the tree-clothed mountain side clear to the gorge below. Great trees trembled, swayed, and fell with a mighty crash upon their comrades. The volume of water in the Otira swelled prodigiously. Huge boulders—big as wagons—in the course of the torrent, became undermined, they trembled and toppled over, releasing other smaller boulders—smaller, yet tons in

weight; and these were carried on, to jam, and enclose small lakes; presently to be in motion again, suddenly liberating the water, which rushed forward with the roar of a bursting reservoir. In two days we were able to resume our journey. But how changed the road! The macadam was washed away to the bare rock; in places the very direction of the road had to be altered.

What must have been the gouging and grinding power of these primitive torrents! Think of the rainfall resulting from the steam and vapors in the atmosphere, equivalent to a mile of water covering the entire earth! What enormous masses of sediment such erosions would send to the bottom of the oceans are shown by the immense deltas of our great rivers. With moisture in the atmosphere so enormously greater than now, the time came when snow could fall on the poles, and tremendous glaciers—smoothing and sculpturing the earth—would be formed. Then, again, owing to the conical motion of the earth's axis, and to the eccentricities in its orbit, alternate torrid and frigid climates would follow each other over and over again from hemisphere to hemisphere. As the earth cooled, more and more water would be deposited, and the alkaline and other metallic oxides, especially the soluble ones, such as lime, would combine with carbonic acid, and be deposited as carbonates. The torrents of hot water, bearing heavy rock and *débris* of all kinds, would be powerfully erosive, and the eroded matter, as already suggested, would tend gradually to cover the ocean's bed with sedimentary rocks. These, in very thick deposits, would be subject to extreme pressure and to heat from the interior, and would be converted into what are called metamorphic or altered rocks, like quartzite—which seems to have been originally a sandstone.

EARTH-SCULPTURING.

As the temperature of the surface of the earth sinks, a new action comes into play. The cooling and contraction of the crust becomes slower and slower, until the internal part is cooling by conduction almost at the same rate as the external part by radiation. The atmosphere has greatly decreased, most of the water is deposited, much

of the carbonic acid has become fixed; the sun's rays are, therefore, becoming more able to penetrate to the surface of the globe. The sun has diminished exceedingly in size, while its temperature has proportionately increased; for, remarkable as it may appear, the more heat a gaseous world gives out, the hotter it grows. As it shrinks, the pressure resulting from the increased gravitation reduces the internal layers to smaller and smaller bulk, thus causing a tremendous increase in the quantity of heat. A gaseous sun, in becoming compressed to one-half its volume, gives off enormous quantities of heat, yet it is double the temperature when it has shrunk to one-half the diameter.

Heat whose source is at a very high temperature can penetrate gases and vapors much more easily than heat from a comparatively moderate source. Hence from these two causes much more heat reaches the crust of the earth, and retards the lowering of its tropical surface temperature. A time ensues comparatively free from volcanic and earthquake disturbances, and at this stage—during a glacial period—it is probable that the earth became cool enough in places to permit plant life to commence at one of the poles. How this may have occurred we will discuss further on. At present we must be content to take a rapid survey of the physics of the earth's crust.

We have traced the molten earth in its process of cooling. We have taken an imaginary glance at the solidifying of the surface, and have seen how, by the hardened rocks sinking down, this solidification would extend to great depths. We have noted that, when solid, the surface would tend to cool more quickly than the interior; and how, shrinking and exerting enormous tension and pressure, it would split, and the interior would be forced out in a molten state; the heat producing this state being largely the energy of the pressure itself. We have traced the oscillations of levels which water and the deposit of sediment would produce, and then the gradual reduction of the temperature of the surface, until solar heat would tend to retard surface cooling, and external and internal

contractions would proceed at almost equal rates. A period of comparative quiet would ensue. Then, after a time, the gain of heat from the sun would balance the surface loss, and the crust would cease to cool and contract. Now a new order of events begins to operate. The hot interior loses heat by conduction through the crust, and continues to shrink, while the crust gets to be too big for the contracted contents of the globe; and, just as the loss of water from a shrivelling apple causes the surface to wrinkle, so the shrinking interior of the earth must cause its surface to crush and wrinkle, and a second period of convulsions ensues. During this time great earthquakes would cause the whole earth to shiver, as the rigid crust crumpled up in its efforts to fit the contracted interior. More and more slowly would the heat pass from the interior until the comparative quiet of the present period was reached.

Thus, then, there are two great agencies producing volcanic action. First, the cooling of the solid crust being more rapid than the internal cooling, the surface shrinks and splits; then, after a pause in the paroxysms, the crust ceases to cool and contract, whilst the continued cooling and contracting of the interior cause it to shrink away from its crust, and the crust begins to crush and crumple to fit its contracted interior.

Probably it was during the interglacial periods occurring in the pause between the earlier volcanoes of surface tension and the later volcanoes of surface crumpling that the enormous forests of the carboniferous period clothed wide regions of the earth and formed our chief coal formations; storing up the solar energy of those far-gone ages to supply man in this present period of conflict and unrest.

Thus the earth has passed through its period of tight crust and splitting to a period of quiescence, and now we must consider in detail how the tight crust has to wrinkle and accommodate itself to its shrinking interior. Apparently inextricable sets of agencies are put in operation by the crumpling of the earth's surface. Let us try to disentangle some of them. Owing to the inequality in

thickness and strength of the crust, the chief crumpling would take place in the weakest parts; often, probably, the margins of continents. Sometimes the earth's surface would buckle up so much as to form mountain ranges; then, along the tops of these new ridges immense splits would open that would become wider and deeper as the crumpling continued; rain would fall upon the rents and torrents rush down them; so the fissures would become valleys. Along the far-dissevered sides of some of these mountain valleys the rock strata, once continuous, may be traced at the present day for miles. Sometimes the efforts of the crust to fit itself to its shrinking contents would produce such tremendous pressure as to heat and fuse the rock; the molten substance would find vent and volcanoes be produced; the hot erupted matter would melt the sides of the outlets and form, in time, circular craters overflowing and forming the slopes of great volcanic cones. As each outrush was exhausted the matter in the vent would solidify and the crater become a reservoir to catch and hold water, which would boil off and so rob the glowing rock of its heat. By-and-by, the pressure would renew itself, again bursting through all obstacles in tremendous eruption; but before the upward pressure exploded through the bottom of the crater, the whole of the original walls of the volcano would be split by fissures radiating from the vent. Into these fissures the fresh molten matter would flow, forming volcanic "dykes."

Many of our mountain chains have been produced by the crumpling and bulging of strata; but, in other cases, the stratified rock material has probably been thrust by lateral pressure up the mountain ridges, produced ages before by the great splits of the primitive volcanic period of tension.

But of the complications of earth-sculpturing agencies there appears to be no end. In addition to the two volcanic periods of tension and pressure and the erosive action of boiling torrents, there came into force—as soon as snow could fall upon the earth—another tremendous factor in modifying surface conditions, namely, glacia-

tion, or the results of ice. Snow would settle on the poles and accumulate there; it would cap all the higher mountains and gradually spread downwards, advancing from the poles toward the polar circles. An astronomic influence of surpassing potency must here be considered. The orbit of the earth is an ellipse—an ellipse may be seen in a hoop leaning a little away. Generally the earth's orbit is nearly a circle, but sometimes, owing to attractions of the other planets, it becomes a long ellipse, the sun being at one of the foci, that is, near one of the smaller curves of the orbit. In extreme cases the earth may be 13,000,000 miles nearer the sun at one part of its annual revolution than at another; at present the difference is only 2,000,000 miles. Now, summer is not due to proximity to the sun, for we may be nearest at midwinter. The seasons are caused by the leaning of the axis of the earth. In the summer hemisphere the axis leans toward the sun, and the directness of the rays causes the high temperature. Winter is caused by the axis leaning away from the sun. It is clear that if during, say, the south polar winter, the earth happens to be 13,000,000 miles nearer the sun than it was six months previously, the southern winter will be very mild; but six months later, when the earth has receded 13,000,000 miles from the sun, the winter of the northern hemisphere will be very cold indeed. In that cold winter most of the water will fall as snow instead of rain, and the snow will pile up on the pole, while the summer sun—instead of warming the surface of the soil—will be engaged in melting the snow. The heat may not suffice to do this completely, and next winter will increase the mass of snow. If this accumulative process lasts—as it may—for 13,000 years, the polar snow may creep down into temperate regions, and such a vast cap of ice be produced as to alter the centre of gravity of the earth, so that one hemisphere may have nearly all the water as ice and sea, and the other may have an almost entirely land surface. One polar hemisphere, the oceanic and icy one, will be nearly all frigid, while the other, the continental, will be very temperate, the seasons being almost equable, the summers cool and the winters

without frosts quite to polar regions. Thus, organic life, both animal and vegetable, will increase prodigiously.

ICE AGES.

A glacial epoch lasts, roughly, a hundred thousand years, and two such epochs may follow close on one another. But every 13,000 years the tilt of the earth reverses itself, and opposite poles have mild winters; the ice-cap melting from one pole and forming on the other. There may be several glacial periods in one epoch; for instance, Europe may be for 13,000 years sub-tropical, then, for a like period, arctic; and so on till the time of the epoch is exhausted. In some of these great glacial periods the ice sheet covered Europe. Vast glaciers stretched from the high land of England far out into the Atlantic; in many parts, as the ice was thrust forward hundreds of miles, being lighter than water, it would tend to float; the upward pressure would break it, and huge icebergs would become detached, which, floating farther south, would carry the arctic climate still nearer the tropics.

In our time the southern hemisphere is colder than the northern, but the earth is almost at its least inequality of distance from the sun, and the difference of polar temperature compared to that of a glacial epoch is slight. The winds are now chiefly the result of the uprush of air caused by tropical heat. The area of this uprush travels with the summer alternately into the northern and southern hemispheres; and the vertical sun in crossing the equator alters its latitude quicker than at any other time; so, by this rapid change of latitude of uprush, we get, in spring and autumn, the equinoctial gales. At mid-summer, in either hemisphere, the vertical sun seems to remain almost stationary; we call this time the solstice, that is, the sun standing still. Then for some weeks the medial line of aërial uprush changes but little, and we have a period comparatively free from violent storms. What will happen to this medial uprush in a glacial epoch? Clearly, it will travel away from the icy regions. Now, ocean currents follow winds, hence the equatorial water will be driven into the warm hemisphere, melting

the polar ice, and rendering the earth habitable well within the polar circle; sometimes, possibly, in extreme cases, quite up to the poles. In this way the Gulf Stream of our own period warms northwestern Europe and fits it for human habitation.

The warm equatorial water, being drawn from the chilled hemisphere, causes it to be still more icy; thus many cumulative forces are at work that greatly accentuate the oscillations of climate during a glacial epoch. Many thousands of years of equable temperature clothe the land with vegetation: then, gradually, during long ages, the climate changes, and cold intensifies until ice piles high where plants had luxuriated; and so, as the tilt of the earth's axis reverses itself, vegetation alternates with ice over and over again. In all directions the strata of the earth prove to us the wonderful vicissitudes of climate produced by these epochs; as, for instance, when we find fossil palms and tree-ferns over and underlying ice-scratched boulders and other remains of glaciation. We may imagine the effect of the encroaching arctic climate on the animal kingdom. How the polar mammals, like the bears, would rejoice in their extending area! How the tropical reptiles would wriggle towards the equator! How the gorgeously-plumaged birds and gaily-colored insects would take flight in the same direction! Then, again, we may picture—with tropical climate slowly creeping back—the pines and arctic plants receding up the mountains, and the woolly rhinoceros and the mammoth retreating toward their polar domain once more! Think of the melting ice; the advance of tropical animals and plants to previously temperate regions, of temperate denizens to the arctic world; the entire hemisphere richly verdant—with small oceans, and these in the deeper channels only!

I have already suggested that it was in the pause between the volcanic period of surface tension and that of surface crumpling that the coal measures were deposited. There are many reasons for the belief. The earth was warmer than at present, and the air held more water and more carbonic acid. Geologists, in describing the carbon-

iferous age, tell us of monotonous plains, thousands of miles in extent, relieved by scarcely a hill; a continuous swamp with a dank vegetation, and uncouth creatures crawling amidst it. Such conditions exactly correspond with the period of rest. The crumpling of the earth had but just begun. Great part of the early inequalities had been eroded away, leaving immense plains bounded by huge mountain ridges—the volcanic lines of relief—the splits of tension through which rock matter had finally overflowed in the closing ages of the cooling crust. The agency which produced tension had ceased, and the interior was shrinking as fast as the exterior. Nothing disturbed the physical peace of the earth save glaciation. But this is a tremendous agency. The distinguished cosmic geologist, Croll, suggests that coal is the result of the vegetation of interglacial periods. One cannot but wonder that, if this were so, the beds of coal are not much thicker than we find them; but we must remember that bituminous coal may very largely consist of the spores of the various flowerless plants which chiefly composed the coal forests; that the foliage and trunks of these giant club-mosses and the like decayed, leaving fossil remains only here and there; while the less perishable, encased, resinous spores, gradually built up our coal deposits. On this view Croll's explanation seems perfect. We have only to imagine limitless plains of vegetation in the polar hemisphere luxuriating for thousands of years without a frost. Then the cold creeps down; ice caps the pole; the oceans deepen, encroaching everywhere upon the land; while clay and other sedimentary material cover the resinous vegetable matter and protect it. Then, again, the axis of the earth reverses its tilt, and for thousands of years the ice melts and disappears, and temperate climate comes once more.

The carboniferous period was rich in limestone deposit. The caustic lime had been slowly turned into carbonate, and this had been dissolved by water and carbonic acid; then, as the warm water flowed toward the pole which was enjoying equable seasons, it would carry with it the young free-swimming or floating stages of corals, stone

lilies, and other marine animals which produce limestone rock. As the polar ice melted, the rock thus formed would be elevated into dry land, and would be covered with *débris* such as wind-swept "loess," becoming the bed upon which new coal forests would grow. Thus was a store of energy laid by, almost entirely in one epoch, for the use of a race that may last 10,000,000 years upon the earth! Ought not this fact to suggest that we should husband our resources for posterity? The cynic may remark that posterity has done nothing for us; but when we realize our indebtedness to the past we must feel our obligations to the future.

Let us now consider the carving and grinding effect of moving ice. As the ice-cap gets thicker and thicker it extends above the lower mountain peaks, and as it slides it grinds them off, forming what the geologists call "hogs' backs." The swollen glaciers carve deep grooves in the sides and bottoms of the valleys, while the ploughing boulders which they bear along are also scratched and ground into glacial silt. From the mountains alongside the sliding glaciers fall immense rocks, which are taken by the glaciers out to sea; and when the glaciers become icebergs and melt, these huge stones are deposited in all sorts of strange declivities in the ocean bed to form gigantic erratic blocks when the sea-bottom becomes elevated into dry land. When, on the other hand, the glacier melts on land the blocks fall and form great ramparts known as terminal moraines. Still the glacier carves the valley deeper and deeper, carrying forward its *débris* to build still higher and thicker the terminal wall, so that when the glacial period is past and the ice melts, deep lakes are left, sometimes on the plains at the base of the mountain ranges, sometimes far up the mountains themselves.

Let us examine and summarize these ice agencies. The eccentric sun produces epochs of about 100,000 years in duration, sometimes closely recurrent. The dates of these epochs are calculable, and furnish us with a geological clock. The last epoch finished some 80,000 years ago; and about 200,000 years ago a still mightier epoch was concluded, having lasted through two periods of

nearly 100,000 years each. We must look back nearly 2,000,000 years before we discern another tremendous epoch, and there the power of the mathematician fails us. Looking forward, we learn that another epoch will arrive in about 800,000 years.

These periods of great eccentricity produce in one polar hemisphere long cold winters and short hot summers, and in the other hemisphere long mild summers and short mild winters. In the glacial hemisphere the summer sun is unable to melt all the snow that fell during the previous long and cold winter, and the snow accumulates. The winter is long as well as cold, because, when the earth is distant from the sun, it has so much further to travel in its orbit and it travels slower. Each year there is more and more snow left unmelted, and fogs are produced that make it difficult for the summer sun to act efficiently; then, as the ice piles up, the tropical uprush of hot air travels away from it, causing winds that carry the warm equatorial water into the warm hemisphere. The cap of ice alters the centre of gravity of the earth, and the mild hemisphere is mainly land, while the frigid one is mainly water. For 13,000 years these agencies act; then, slowly, all is reversed—what belonged to the southern hemisphere now belongs to the northern; another 13,000 years and another reversal happens. The effect of these wonderful changes of environment upon evolution may be pictured by any one who tries to understand the subject, and the same study explains many puzzling problems in the geographical distribution of plants and animals.

But we must turn from these fascinating speculations to the more prosaic problems of the earth's crust. Let us try to answer several questions. Why is nearly all the land in the northern hemisphere? Why do the great peninsulas point to the south? Why are the lofty mountain chains of the temperate regions carved into deep fiords whose precipitous fronts reach deep into the sea? Why are New Zealand northwest winds hot and dry? These problems and some others must be attacked before we are in a position to understand the origin of the lovely

verdant vesture that clothes a great part of the earth's surface.

LAND AND SEA.

A merely superficial glance at the distribution of land on the globe, shows that it mainly lies north of the equator. One searches in vain for any explanation, save that the great Antarctic ice-cap has altered the centre of gravity of the earth, and drawn most of the water away from the northern hemisphere. The ice-cap has an area probably over 3,000,000 square miles; its thickness it is impossible to estimate. Judged by the size of antarctic icebergs, it may be miles thick at its margin where the bergs break off; and possibly many times thicker at the pole. This mass of ice must attract the water and deepen the ocean. Were the ice to melt, the water would become much shallower, because it would be drawn to the northern hemisphere, and a great part of the southern hemisphere would be laid bare as dry land. Judging by the soundings of the Antarctic Ocean, we believe that an enormous continent would result. At the same time, were the ice piled high at the North Pole, it would, by its gravitating power, deepen the Arctic Ocean. The land in the north would shrink, Scandinavia would become an island, and large peninsulas would stretch along the Rocky Mountains toward Alaska, and along Eastern Siberia—two peninsulas corresponding with the southern peninsulas terminated by Cape Horn and the Cape of Good Hope. Then, from the shallow southern seas would emerge a huge continent; the same continent which, possibly, some ten thousand years ago was peopled by the race who have left on Easter Island—an islet in mid-Pacific—the cyclopean masonry and gigantic statues that amaze every chance visitant.

If, as suggested, the Antarctic ice-cap be the explanation of the singularly unequal distribution of land in the two polar hemispheres, the great glacial epochs must have produced a still more striking discrepancy—the temperate hemisphere would be an almost unbroken continent, with a few deep seas, but no oceans.

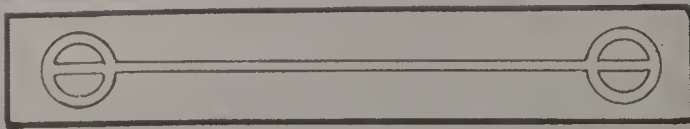
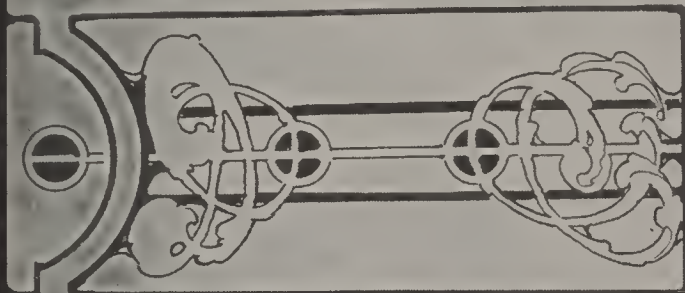
Oscillations of land and sea are not, however, entirely

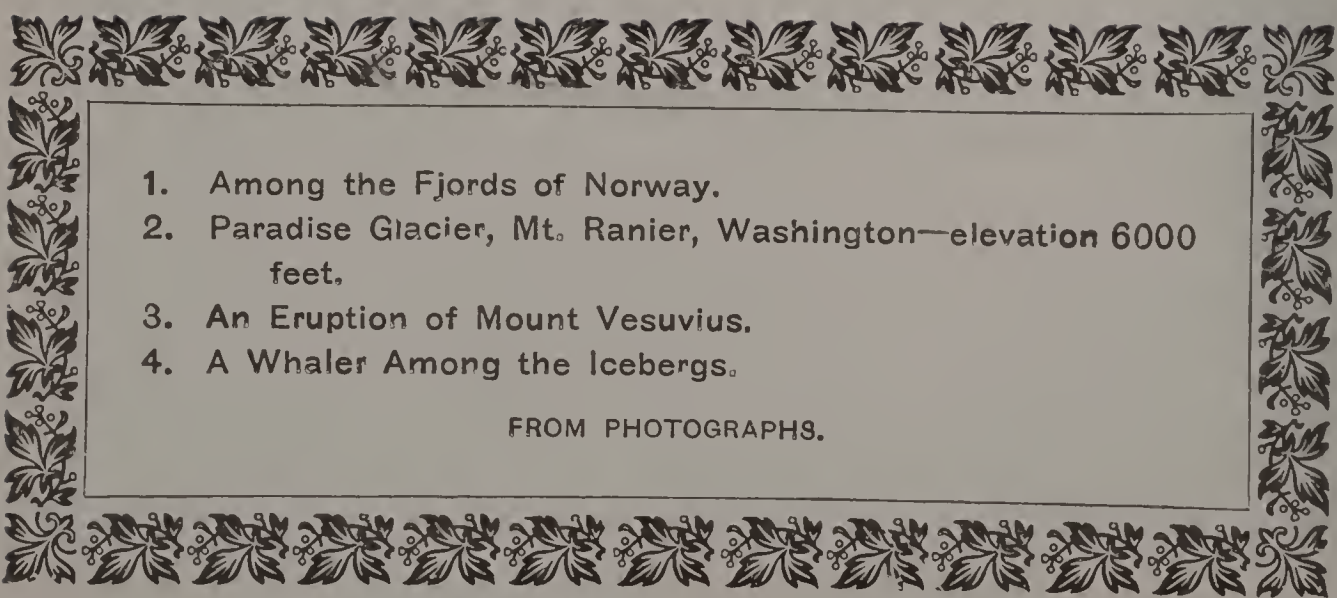
due to the piling of ice at the alternate poles; differences of level are also caused by the crumpling of the crust which results from the efforts of the earth's exterior to fit itself to its shrinking interior, notably, for instance, in such alterations as the simultaneous rising and sinking of opposite coasts of large islands. Again, the crumpling of the crust is not merely producing oscillations of land, but is the primary cause of our present volcanoes and earthquakes, the energy of the crumpling being so tremendous as to fuse the rocks into lava, while the action is still further complicated by the explosive and decomposing effects of high pressure steam produced by the inrush of water to heated fissures and vents.

The lateral pressure produced by the crumpling crust acting on strata of different hardness, plasticity, and thickness, results in contortions and "faults" that are almost incredible. Yet recent experiments on confined layers of materials of different hardness and toughness seem to imitate exactly rocks curved into forms as crooked as the letter S. Sometimes strata fold back on themselves; sometimes the rocks split into vast fissures, whose two surfaces slide thousands of feet over one another, until the continuity of the original strata seems lost altogether; this sliding action grinding the inequalities of the moving faces into powder fine enough to give the rocks the polish of cut gems.

The probable explanation of the wonderful fiords of Norway, western Scotland, western Patagonia, and southwest New Zealand is that these coasts all lie in the path of the anti-trades of which our westerly winds are typical. These winds, becoming saturated in their journey over the ocean, are cooled in ascending mountains, and discharge their moisture, partly as rain, but largely as snow. This frozen water packs itself upon the mountaintops; then, being forced downward by the weight of the constantly forming ice, it forms glaciers, which, in a cold period, descend to the sea, cutting the western sides of the mountains into more and more precipitous fiords.

When these winds blow over a very high range of mountains a peculiar phenomenon ensues; the air be-



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- A decorative border of repeating floral motifs, possibly holly leaves, surrounds the text area.
1. Among the Fjords of Norway.
 2. Paradise Glacier, Mt. Ranier, Washington—elevation 6000 feet.
 3. An Eruption of Mount Vesuvius.
 4. A Whaler Among the Icebergs.

FROM PHOTOGRAPHS.

comes hot and dry, as exemplified in the New Zealand "nor'-westers." Let us try to understand this. In ascending a mountain, air expands and does work in lifting the atmosphere above it. To do work requires heat, and so the air cools in expanding. As it cools, the vapor it contains becomes liquid, and in condensing gives out its so-called latent heat; so, when it reaches the mountain top, the air is not cooled so much as it would have been had it contained no vapor. Then it descends the other side, and the air above it compresses and heats it, and, as it does not take up water again, it becomes hot and dry. If it had been dry when it ascended the mountain, and had produced no rain when it cooled, it would have been equally cooled in ascending and heated in descending; but, because it contained vapor it cooled only slightly in rising and was heated much in coming down again. Hence the New Zealand nor'-west winds, that have had to rise over the range of the Southern Alps, are hotter and drier than they were when they reached the western base of the mountains after travelling across the ocean, and similar winds exist in other parts of the earth.

Besides the physical agencies described, we have the effects of solution and chemical change to discuss. These produce a very interesting set of phenomena; the sculpturing of limestone caves, the growth of stalagmites and stalactites, petrifications, the disintegration of granite rocks with the formation of clay and fertile soils, the building of silicious terraces such as the beautiful pink and white terraces of New Zealand, the growth of geyser tubes and the marvel of their spouting, and so on. If we grind some chalk to a fine powder, suspend a little of it in water, and pass a stream of carbonic acid gas through it, the chalk dissolves, and the water is what we call hard. If we wash our hands in this water, it curdles the soap: if we boil it, it leaves a deposit of lime in the vessel. The air contains carbonic acid produced by fires and by the combustion which goes on more slowly but not less really in the bodies of living creatures. When rain falls, it absorbs the carbonic acid, and this water, running through the fissures of a limestone district, dissolves the

rocks away, and in the course of ages, carves out the extensive limestone caves that are often so very beautiful. Much of their beauty is due to the lime borne by the water having been deposited in translucent masses—called stalactites—that hang from the roof; while corresponding pinnacles—stalagmites—grow by the dropping water leaving its lime on the floor; stalactites and stalagmites frequently lengthening until they meet and thicken into lovely columns. When the water oozes up from the floor of the cave it erects a ring of lime that grows higher into tubes, or widens into basins that form exquisite fountains. When it issues from the cracks in the ceiling it produces curtains of petrified drapery, partitioning one chamber from another. When it flows over plants and through the pores of wood it coats the cells with stone, and makes permanent record of the vegetation of the past. When it passes out to sea, various molluscs, crustacea, stone lilies, corals, zoophytes, and micro-organisms take it into their bodies and use it, making their exquisite shells or skeletons. These, on the decay of the living architects, go to form fresh beds of chalk and limestone, that, under conditions of heat, pressure, etc., may crystallize into marble and other beautiful forms of carbonate of lime.

But water-bearing carbonic acid not merely dissolves some rocks; it decomposes others, taking the place of flint or silica. Thus felspar, a constituent of granite, is decomposed into materials such as clay and carbonate of potash, that tend to give fertility to soils in granitic districts. I have seen granitic rock so decomposed in this way that a walking stick could be driven some inches into it. The silica that is thus expelled by carbonic acid may remain in solution in hot water, to be deposited on the margin of pools, building the pools larger, and growing into such formations as those of the silicious terraces of the North Island of New Zealand destroyed by the eruption of Tarawera. If such hot water ooze out of a hole in the ground it will deposit the silica in a circle, building up higher and higher until the circle becomes a tube with sloping walls of silica. Then, if the bottom heat in-

creases, we have a geyser which spouts when its water comes to the boiling point. The spouting of a geyser is a very interesting phenomenon. After each discharge the water gradually fills the tube, increasing in temperature the lower its position. Owing to the pressure, the water at the bottom gets to be much above the ordinary boiling point. At last it boils and lifts the water above it, then, the pressure being relieved, the surplus heat produces a volume of steam vast enough to blow the entire contents of the tube scores of feet into the air. Geysers are of many different varieties, but the physical principles are practically the same for all.

These are some of the mechanical, physical, and chemical agencies that have aided in moulding and sculpturing the surface of the earth.

WHAT OUR EARTH TEACHES US AS TO OTHER WORLDS THAN OURS.

BY

RICHARD A. PROCTOR.

BEFORE proceeding to consider the various circumstances under which the worlds or systems which surround us appear to subsist, it may be well to inquire how far we have reason to conclude, from the consideration of our own earth, that other orbs in space support life.

It would not be just to argue directly from the fact that the earth is inhabited to the conclusion that the other planets are inhabited also, nor thence to the conclusion that other stars have, like our sun, their attendant worlds, peopled with various forms of life. An analogy founded on a single instance has no logical force. And it is doubtful whether we have not, in the moon, an instance which would as effectually serve to support a directly opposite conclusion. It seems all but certain, as we shall presently

have occasion to show, that no part of the moon's globe is inhabited by living creatures. Certainly she is inhabited by none which bear the least resemblance to those existing on our earth. Thus it might fairly be urged that, since one of the two orbs respecting which we know most appears to be uninhabited, there remains no probable argument in favor of the view that other orbs besides our earth are the abode of living creatures.

Yet the earth in reality supplies an argument of great force, when we consider the evidence she presents in another light. The mere fact that this world is inhabited is, as we have seen, little; but we shall find that the way in which life is distributed over the earth's surface is full of significance.

If we range over the earth, from the Arctic regions to the torrid zone, we find that none of the peculiarities which mark the several regions of our globe suffice to banish life from its surface. In the bitter cold within the Arctic Circles, with their strange alternations of long summer days and long winter nights, their frozen seas, perennial ice, and scanty vegetation, life flourishes in a hundred various forms. On the other hand, the torrid zone, with its blazing heat, its long-continued droughts, its strange absence of true seasonal changes, and its trying alternations of oppressive calms and fiercely raging hurricanes, nourishes even more numerous and more various forms of life than either of the great temperate zones. Around mountain summits as in the depth of the most secluded valleys, in mid-ocean as in the arid desert, in the air as beneath the surface of the earth, we find a myriad forms of life.

But this is far from being all. Various as are the physical habitudes which we encounter as we travel over the surface of our globe, we are able to trace the existence of other varieties even more remarkable. The geologist has been able to turn back a few leaves of the earth's past history, and though the pages have been defaced and mutilated by Time's unsparing hand, he is yet able to read in them of many strange vicissitudes to which the continents and oceans of our globe have been

exposed. But, far back as he can trace the earth's history—and already he counts her age by millions of years—he finds no evidence of an epoch when life was absent from her surface. Nay, if he reads aright the mysterious lesson which the blurred letters teach him, he is led to believe that, at the most distant epoch to which his researches have extended, there was the same wonderful variety in the forms of life as at the present day. He can, indeed, find the scattered remains of only a few of those old-world creatures; but he recognizes in those which have been preserved the clearest evidence that thousands of others must have existed around them. He knows that of a million creatures now existing scarcely one will leave to future ages any record of its existence; he sees whole races vanishing from the earth, leaving no trace behind them; and he is thus able to form an estimate of the enormous extent by which the creatures and races of which he can learn *nothing* must have outnumbered those whose scattered remains attest their former existence upon the earth.

Here, then, we have analogies which there is no mistaking. We see that not only is Nature careful to fill all available space with living forms, but that no time over which our researches extend has found her less prodigal of life. We see that, within very wide limits, she has a singular power of adapting living creatures to the circumstances which surround them. Nor is this lesson affected—like the general lesson drawn from the mere fact of the earth's being inhabited—by anything we can learn from the aspect of our satellite. For the arguments against the presence of living creatures on the moon are founded on the evidence we have that the physical habits of that orb are outside the limits within which Nature effects the adaptation spoken of.

The moon teaches us, however, that all the celestial bodies are not at all times habitable. The sun also teaches the same lesson. And it is necessary that we should consider how far the evidence presented by our own earth may serve to elucidate this teaching. We shall see that terrestrial analogies afford a very sure guide in the midst

of many perplexities presented by the study of the worlds around us.

Let us trace out the various degrees of fitness or unfitness for the support of particular forms of life, which we recognize in various regions of our earth.

Often, where there exists so slight a difference between two regions of the earth that, to ordinary observation, it would appear that the forms of life existing in one should be well adapted to the other also, we yet find that this is not the case. Some minute peculiarity of soil, or climate, or vegetation, will render one region absolutely uninhabitable by a race which lives and thrives in the other. Darwin mentions several instances in which an apparently insignificant change in the circumstances under which a particular race has thriven, and sometimes a change which does not, at first sight, appear to be in the least connected with the well-being of the race, has led to its gradual disappearance. And it seems demonstrated that even the slow processes of change to which every part of the earth is subjected would suffice to destroy a number of the races now subsisting on its surface, were the characteristics of those races unalterable. But as the physical habitudes of their abode slowly change, the various races of living creatures slowly change also, so as to adapt themselves continually to the varying circumstances under which they live.

The lesson taught us by this peculiarity is very obvious. On the one hand, we see that it would be by no means sufficient to indicate a general resemblance between the physical habitudes of our earth and those of some far distant planet, in order to prove that that planet is the abode of living creatures resembling those on our own earth. But, on the other hand, we are taught that the existence of differences sufficient to render a distant planet an unsuitable abode for such creatures as we are familiar with cannot force upon us the conclusion that the planet is uninhabited. On the contrary, the circumstance we have been considering teaches us that such differences as would suffice to banish life of certain kinds are insufficient to banish life of all kinds, or even to ren-

der less abundant the forms of life which exist under those changed conditions.

And now we may proceed a step farther. On our earth we find differences of climate and of physical habitudes generally, which are much more important than those hitherto dealt with. We see that not only would certain races perish in the long run, if removed from their own abode to other parts of the earth, but that, in some instances, the process of destruction would be very rapid indeed. If we were to remove the polar bears from their Arctic fastnesses to tropical, or even to the warmer parts of temperate regions, a very few years would see the end of the whole race. The races inhabiting steppes and prairies would quickly perish if removed to mountain regions. Those accustomed to a moisture-laden air and abundant vegetation would not survive long if removed to the desert.

In some races, indeed, we find a power of enduring such changes which very far exceeds that possessed by other races. Those creatures, for example, which man has domesticated seem capable of enduring a variety of climate or of circumstances, which would destroy the seemingly more vigorous races not yet subdued to the yoke of man.*

Even man himself, however, though he possesses in an unrivalled degree the power of enduring in safety the most complete change of climate, scene, and circumstances, is yet limited, in a certain sense, in his power of migration. The Englishman, for example, can endure the fiercest heat of the tropics or the bitterest cold of Arctic and Antarctic regions. But he cannot safely attempt to found true colonies in every part of the earth's surface. The Englishmen in India must send their children to be reared in England, if they wish them to grow up strong and vigorous. There can be little doubt that if a thousand men and women from England were to

*Humboldt tells us that "the pliability of the organization of those animals which man has subjected to his sway enables horses, cows, and other species of European origin to lead for a time an amphibious life, surrounded by crocodiles, water-serpents, and manatees. When the rivers return again to their beds, the horses roam in the savannah, which is then spread over with a fine odoriferous grass; and enjoy, as in their native climate, the renewed vegetation of spring."

settle in certain parts of India (not at any time intermarrying with the natives), the colony would disappear within a couple of centuries.

Here we have a second degree of unfitness, according to which certain countries would quickly become depopulated, if supplied with inhabitants from certain other countries. We are taught the same lesson as before, but in a more striking manner. We see that differences exist within the confines of our own earth which render particular countries absolutely uninhabitable by particular races, insomuch that, though the individual might survive, the race itself would quickly perish. And we see, on the other hand, that these countries are not uninhabited, or even less fully peopled with living creatures, than seemingly more fortunate abodes.

Now, if some impassable barrier prevented the inhabitants of one country from visiting others, while yet it was possible to learn something of the conditions prevailing in other regions, how readily the conclusion might be reached that some at least of those inaccessible regions must be wholly uninhabited, simply because their physical habits appeared unsuited to the wants of the only creatures with which the observer was familiar. Who would believe, for example, that men can live, and not only live but thrive and multiply, in the frost-bound regions within the Arctic Circle, if travellers had not visited the Esquimaux races, and witnessed the conditions under which they subsist? Again, if we knew nothing of India, and some one pictured to us the intense heat of the Indian sun, the strange alternations of weather which replace to the Indian the seasonal changes we are familiar with, and all the other circumstances which render tropical regions so different from the English home, who could believe that, amidst those seemingly unendurable vicissitudes, there are races of men that thrive and multiply, even as our people in their temperate zone?*

*Perhaps the most striking instance of man's power of living under circumstances seemingly the most unfavorable is to be found in the fact that though the strongest traveller is affected seriously by the rarity of the air at great elevations, yet races of men live and thrive in Potosi, Bogotá, and Quito, and—to use the words of a modern writer—that bull-fights should be possible at an elevation at which Saussure hardly had energy to consult his instruments, and where even his guides fainted as they tried to dig a small hole in the snow.

Therefore, in examining the circumstances of other worlds than ours, it will not be sufficient to prove that certain orbs would obviously not be habitable by the races subsisting on the earth, in order to enforce the conclusion that no living creatures subsist at all upon their surface.

Yet another step farther, however. There are regions of the earth where the members of races belonging to other regions *quickly* perish. The air of England is death to many creatures. And, indeed, there is not a spot in the whole world which would not be fatal in a brief space to many animals and plants belonging to other regions. Yet each spot, though thus fatal to certain races, is inhabited by numbers of others which live and thrive upon its surface.

Here, then, is our third lesson. We are taught by the analogy of our earth that it is not even sufficient to show that a planet would be an abode quickly fatal to all the living creatures subsisting on our globe to prove that it is therefore uninhabited.

But we have yet a stronger argument to touch on. There are regions of our earth to which creatures from other regions cannot be removed without being *immediately* killed. The warm-blooded animal perishes if placed for a brief space under water. The fish perishes if placed for a brief space on the earth.* What could be more wonderful to us, were we not familiar with the fact, than that there are living creatures within the depth of that ocean beneath whose surface we ourselves, and the land creatures we are familiar with, cannot remain alive many minutes? If fishes could reason, how could they believe that creatures can live in comfort in that element which is death to them? Yet land and river and sea are alike peopled with living creatures, each race as well adapted as its fellows to the circumstances in which it is placed.

We are taught, then, yet another lesson. We see that

*Perhaps the fact that there are certain kinds of fish which can not only live out of water, but can travel across dry land, or climb trees, affords an even more striking instance of Nature's power of adapting creatures to the circumstances which surround them.

even though we could prove that every living creature on this earth would at once perish if removed to another orb, yet we cannot thence conclude that that orb is uninhabited. On the contrary, the lesson conveyed by our earth's analogy leads to the conclusion that many worlds may exist, abundantly supplied with living creatures of many different species, where yet every form of life upon our earth—bird, beast, or fish, reptile, insect, or animalcule—would perish in a few moments.*

There remains yet a last lesson to be drawn from terrestrial analogies. On the earth there are regions where no form of life exists or can exist. Within the flaming crater of the volcano, or in the frozen heart of the iceberg, no living creature has its being. Yet even here Nature proves to us that the great end and aim of all her working is to afford scope and room for new forms of life, or to supply the wants of those which already exist. The volcano will die out, and the scene of its activity will one day become the abode of myriads of living creatures who would have perished in a moment in its consuming fires. The iceberg will melt, and its substance will once again be peopled with busy life. But this is little. It is the work of which volcano and iceberg are the signs, which most significantly teaches us what is Nature's real aim. The volcano is the index of those busy subterranean forces which are remodelling the earth's frame, slowly changing the level of the land, making continents of oceans and oceans of continents, preserving and vivifying all things, while all things seem to suffer a gradual destruction. The iceberg, too, has its work in remodelling and fashioning the surface of new continents. It also acts an important part in the formation and maintenance of the system of oceanic circulation on which the welfare of land creatures and water creatures so largely depends. And so of a multitude of other phenomena, which appear

*I might add to the instances here cited many others which seem even more striking. We know that in strong acids which would instantly kill bird, beast, fish, or insect placed within them, there exist and thrive minute creatures, adapted by Nature to the strange conditions in which they are placed. Even in the bowels of the earth and in the very neighborhood of active volcanoes, we find the Volcano-fish existing in such countless thousands that when they are from time to time vomited forth by the erupting mountain their bodies are strewn over enormous regions, and, as they putrefy beneath the sun's rays, spread pestilence and disease among the inhabitants of the neighboring districts.

at first sight significant rather of the destructive than of the life-preserving character of Nature. The tornado and the thunder-storm, the earthquake and the volcano—nay, even the dreaded returns of plague and pestilence,—have each a more powerful influence by far towards the preservation than they have towards the destruction of life.

We see, then, that even if we could prove that an orb in space is so circumstanced that no life could by any possibility exist upon its surface; if it were the scene of a fierce and destructive turmoil, one moment of which would suffice to destroy every living creature now existing upon the earth; if its whole mass were heated to a degree a thousandfold more intense than that of the fiercest heat we know of; if its surface were bound in a cold compared with which our Arctic frosts would seem like tropical heat; or even if the most rapid alternation of these extremes took place upon and within it—even then we could not conclude that it has not been in long-past ages, or will not be in ages yet to come, the abode of life.

Lastly, even when we can safely assert of any celestial object that neither now, nor at any past or future time, could it serve as the abode of living creatures, we are led by terrestrial analogies to the conclusion that it yet supports life in other ways. So that these very orbs, of which it seems safest to assert that they are, have ever been, and must ever remain uninhabited, speak to us, no less strongly than those which appear best suited for habitation, of the existence of other worlds than ours.

WHAT IS GEOLOGY?

BY

SIR ARCHIBALD GEIKIE, F. R. S.

THE main features of the dry land on which we live seem to remain unchanged from year to year. The valleys and plains familiar to our forefathers are still familiar to us, bearing the same meadows and woodlands, the same hamlets and villages, though gen-

eration after generation of men has meanwhile passed away. The hills and mountains now rise along the skyline as they did long centuries ago, catching as of old the fresh rains of heaven and gathering them into the brooks and rivers which, through unknown ages, have never ceased to flow seawards. So steadfast do these features appear to stand, and so strong a contrast do they offer to the shortness and changeableness of human life, that they have become typical in our minds of all that is ancient and durable. We speak of the firm earth, of the everlasting hills, of the imperishable mountains, as if, where all else is fleeting and mutable, these forms at least remain unchanged.

And yet attentive observation of what takes place from day to day around us shows that the surface of a country is not now exactly as it used to be. We notice various changes of its topography going on now, which have doubtless been in progress for a long time, and the accumulated effect of which may ultimately transform altogether the character of a landscape. A strong gale, for instance, will level thousands of trees in its pathway, turning a tract of forest or woodland into a bare space, which may become a quaking morass, until perhaps changed into arable ground by the farmer. A flooded river will in a few hours cut away large slices from its banks, and spreading over fields and meadows, will bury many acres of fertile land under a covering of barren sand and shingle. A long-continued, heavy rain, by loosening masses of earth or rock on steep slopes, causes destructive landslips. A hard frost splinters the naked fronts of crags and cliffs, and breaks up bare soil. In short, every shower of rain and gust of wind, if we could only watch them narrowly enough, would be found to have done something towards modifying the surface of the land. Along the sea margin, too, how ceaseless is the progress of change. In most places, the waves are cutting away the land, sometimes even at so fast a rate as two or three feet in a year. Here and there, on the other hand, they cast sand and silt ashore so as to increase the breadth of the dry land.

These are ordinary everyday causes of alteration, and though singly insignificant enough, their united effect after long centuries cannot but be great. From time to time, however, other less frequent but more powerful influences come into play. In most large regions of the globe, the ground is often convulsed by earthquakes, many of which leave permanent scars upon the surface of the land. Volcanoes, too, in many countries pour forth streams of molten rock and showers of dust and cinders that bury the surrounding districts and greatly alter their appearance.

Turning to the pages of human history, we find there the records of similar changes in bygone times. Lakes, on which our rude forefathers paddled their canoes and built their wattled island-dwellings, have wholly disappeared. Bogs, over whose treacherous surface these early hunters could not follow the chase of red deer or Irish elk, have become meadows and fields. Forests, where they hunted the wild boar, have been turned into grassy pastures. Cities have been entirely destroyed by earthquakes or have been entombed under the piles of ashes discharged from a burning mountain. So great have been the inroads of the sea that, in some instances, the sites of what a few hundred years ago were farms and hamlets, now lie under the sea half a mile or more from the modern shore. Elsewhere the land has gained upon the sea, and the harbors of an earlier time are now several miles distant from the coast-line.

But man has naturally kept note only of the more impressive changes; in other words, of those which had most influence upon his own doings. We may be certain, however, that there have been innumerable minor alterations of the surface of the land within human history, of which no chronicler has made mention, either because they seemed too trivial, or because they took place so imperceptibly as never to be noticed. Fortunately, in many cases, these mutations of the land have written their own memorials, which can be as satisfactorily interpreted as the ancient manuscripts from which our early national history is compiled.

In illustration of the character of these natural chronicles, let us for a moment consider the subsoil beneath cities that have been inhabited for many centuries. In London, for example, when excavations are made for drainage, building, or other purposes, there are sometimes found, many feet below the level of the present streets, mosaic pavements and foundations together with earthen vessels, bronze implements, ornaments, coins, and other relics of Roman time. Now, if we knew nothing, from actual authentic history, of the existence of such a people as the Romans, or of their former presence in England, these discoveries, deep beneath the surface of modern London, would prove that long before the present streets were built, the site of the city was occupied by a civilized race which employed bronze and iron for the useful purposes of life, had a metal coinage, and showed not a little artistic skill in its pottery, glass, and sculpture. But down beneath the rubbish wherein the Roman remains are embedded, lie gravels and sands from which rudely-fashioned human implements of flint have been obtained. Whence we further learn that, before the civilized metal-using people appeared, an earlier race had been there, which employed weapons and instruments of roughly chipped flint.

That this was the order of appearance of the successive peoples that have inhabited the site of London is, of course, obvious. But let us ask ourselves why it is obvious. We observe that there are, broadly speaking, three layers or deposits from which the evidence is derived. The upper layer is that which contains the foundations and rubbish of modern London. Next comes that which encloses the relics of the Roman occupation.* At the bottom lies the layer that preserves the scanty traces of the early flint-folk. The upper deposit is necessarily the newest, for it could not be laid down until after the

*A practical demonstration of the foregoing occurred within the experience of the Managing Editor. When, in 1885, the old house at the corner of St. Paul's Churchyard, London, which was founded by John Newbery (Goldsmith's friend and publisher), was torn down and new foundations had to be made, the excavators after coming upon traces of a Roman pavement found several feet lower down the remains of an old British wattle road—that is to say, a road which was made of the branches of trees and reeds intertwined. It had been well known for centuries that the Celts so made their roads, but this was one of the most perfect examples that was ever unearthed.

accumulation of those below it, which must, of course, be progressively older, as they are traced deeper from the surface. By the mere fact that the layers lie one above another, we are furnished with a simple clue which enables us to determine their relative time of formation. We may know nothing whatever as to how old they are measured by years or centuries. But we can be absolutely certain of what is termed their "order of superposition," or chronological sequence; in other words, we can be confident that the bottom layer came first and the top layer last.

This kind of observation and reasoning will enable us to detect almost everywhere proofs that the surface of the land has not always been what it is to-day. In some districts, for example, when the dark layer of vegetable soil is turned up which supports the plants that keep the land so green, there may be found below it sand and gravel, full of smooth well-rounded stones. Such materials are to be seen in the course of formation where water keeps them moving to and fro, as on the beds of rivers, the margins of lakes, or the shores of the sea. Wherever smoothed rolled pebbles occur, they point to the influence of moving water; so that we conclude, even though the site is now dry land, that the sand and gravel underneath it prove it to have been formerly under water. Again, below the soil in other regions, lie layers of oyster and other sea-shells. These remains, spread out like similar shells on the beach or bed of the sea at the present day, enable us to infer that where they lie the sea once rolled.

Pits, quarries, or other excavations that lay open still deeper layers of material, bring before us interesting and impressive testimony regarding the ancient mutations of the land. Suppose, by way of further illustration, that underneath a bed of sand full of oyster-shells, there lies a dark brown band of peat. This substance, composed of mosses and other water-loving plants, is formed in boggy places by the growth of marshy vegetation. Below the peat there might occur a layer of soft white marl full of lake-shells, such as may be observed

on the bottoms of many lakes at the present time. These three layers—oyster-bed, peat, and marl—would present a perfectly clear and intelligible record of a curious series of changes in the site of the locality. The bottom layer of white marl with its peculiar shells would show that at one time the place was occupied by a lake. The next layer of peat would indicate that, by the growth of marshy vegetation, the lake was gradually changed into a morass. The upper layer of oyster-shells would prove that the ground was then submerged beneath the sea. The present condition of the ground shows that subsequently the sea retired and the locality passed into dry land as it is to-day.

It is evident that by this method of examination information may be gathered regarding early conditions of the earth's surface, long before the authentic dates of human history. Such inquiries form the subject of Geology, which is the science that investigates the History of the Earth. The records in which this history is chronicled are the soils and rocks under our feet. It is the task of the geologist so to arrange and interpret these records as to show through what successive changes the globe has passed, and how the dry land has come to wear the aspect which it presents at the present time.

Just as the historian would be wholly unable to decipher the inscriptions of an ancient race of people unless he had first discovered a key to the language in which they are written, so the geologist would find himself baffled in his efforts to trace backward the history of the earth if he were not provided with a clue to the interpretation of the records in which that history is contained. Such a clue is furnished to him by a study of the operations of nature now in progress upon the earth's surface. Only in so far as he makes himself acquainted with these modern changes, can he hope to follow intelligently and successfully the story of earlier phases in the earth's progress. It will be seen that this truth has already been illustrated in the instances above given of the evidence that the surface of the land has not been always as it is now. The beds of sand and gravel, of oyster-shells, of

peat and of marl, would have told us nothing as to ancient geography had we not been able to ascertain their origin and history by finding corresponding materials now in course of accumulation. To one ignorant of the peculiarities of fresh-water shells, the layer of marl would have conveyed no intelligible meaning. But knowing and recognizing these peculiarities, we feel sure that the marl marks the site of a former lake. Thus the study of the Present supplies a key that unlocks the secrets of the Past.

In order, therefore, to trace back the history of the Earth, the geologist must begin by carefully watching the changes that now take place, and by observing how nature elaborates the materials that preserve more or less completely the record of these changes.

If the labors of the geologist were concerned merely with the former mutations of the earth's surface,—how sea and land have changed places, how rivers have altered their courses, how lakes have been filled up, how valleys have been excavated, how mountains, peaks, and precipices have been carved, how plains have been spread out, and how the story of these revolutions has been written in enduring characters upon the very framework of the land,—he would feel the want of one of the great sources of interest in the study of the present face of nature. We naturally connect all modern changes of the earth's surface with the life of the plants and animals that flourish there, and more especially with their influence on the progress of Man himself. If there were no similar connection of the ancient changes with once living things—if the history of the earth were merely one of dead inert matter it would lose much of its interest for us. But happily that history includes the records of successive generations of plants and animals which, from early times, have peopled land and sea. The remains of these organisms have been preserved in the deposits of different ages, and can be compared and contrasted with those of the modern world.

To realize how such preservation has been possible, and how far the forms so retained afford an adequate

picture of the life of the time to which they belonged, we must turn once more to watch how nature deals with this matter at the present time. Of the millions of flowers, shrubs, and trees which year after year clothe the land with beauty, how many relics are preserved? Where are the successive generations of insect, bird, and beast which have appeared in this country since man first set foot upon its soil? They have utterly vanished. If all their living descendants could suddenly be swept away, how could we tell that such plants and animals ever lived at all? It must be confessed that the vast majority of them leave no trace behind. Nevertheless we should be able to recover relics of some of them by searching in the comparatively few places where, at the present day, dead plants and animals are entombed and preserved. From the alluvial terraces of rivers, from the silt of lake-bottoms, from the depths of peat-mosses, from the floors of subterranean caverns, from the incrustations left by springs, we might recover traces of some at least of the living things that people the land. And from these fragmentary and incomplete records we might conjecture what may have been the general character of the life of the time. By searching the similar records of earlier ages the geologist has brought to light many profoundly interesting vestiges of vegetation and of animal life belonging to types that have long since passed away.

It must be evident, however, that were we to confine our inquiries merely to its surface, we should necessarily gain a most imperfect view of the general history of the Earth. Beneath that surface, as volcanoes show, there lies a hot interior, which must have profoundly influenced the changes of the outer parts or crust of the planet. The study of volcanoes enables us to penetrate, as it were, a little way into that interior, and to understand some of the processes in progress there. But our knowledge of the inside of the Earth can obviously be based only to a very limited extent on direct observation, for man cannot penetrate far below the surface. The deepest mines do not go deep enough to reach materials differing in any essential respect from those visible

above ground. Nevertheless, by inference from such observations as can be made, and by repeated and varied experiments in laboratories, imitating as closely as can be devised what may be supposed to be the conditions that exist deep within the globe, some probable conclusions can be drawn even as to the changes that take place in those deeper recesses that lie forever concealed from our eyes.

I have compared the soils and rocks with which geology deals to the records out of which the historian writes the chronicles of a nation. We might vary the simile by likening them to the materials employed in the construction of a great building. It is of course interesting enough to know what kinds of marble, granite, mortar, wood, brass, or iron, have been chosen by an architect. But much more important is it to inquire how these various substances have been grouped together so as to form such a building. In like manner, besides the nature and mode of origin of the various rocks of which the visible and accessible part of the earth consists, we ought to know how these varied substances have been arranged so as to build up what we can see of the outer part or crust of our globe. In short, we should try to trace what may be called the architecture of the planet, noting how each variety of rock occupies its own characteristic place, and how they are all grouped and braced together in the solid framework of the land.

But in a great historical edifice, like one of the Gothic minsters of Europe, for example, there are often several different styles. A student of architecture can detect these distinctions, and by their means can show that a cathedral has not been completed in one age; that it may even have been partially destroyed and rebuilt during successive centuries, only finally taking its present form after many political vicissitudes and many changes of architectural taste. Each edifice has thus a separate history, which is recorded by the way the materials have been shaped and put together in the various parts of the masonry. So it is with the architecture of the Earth. We have evidence of many demolitions and rebuildings,

and the story of their general progress can still be deciphered among the rocks. It is the business of Geology to trace out that story, to put all the scattered materials together, and to make known by what a long succession of changes the Earth has reached its present state.

Looking upon Geology as the study of the Earth's history, we need not at first concern ourselves with any details, save those that may be needed to enable us clearly to understand what the general character and progress of this history have been. In a science which embraces so vast a range as Geology, the multiplicity of facts to be examined and remembered may seem at first to be almost overwhelming. But a selection of the essential facts is sufficient to give the learner a clear view of the general principles and conclusions of the science, and to enable him to enter with intelligence and interest into more detailed treatises. In the second place, Geology is essentially a science of observation. The facts with which it deals should, as far as possible, be verified by our own personal examination. We should lose no opportunity of seeing with our own eyes the actual progress of the changes which it investigates, and the proofs which it adduces of similar changes in the far past. To do this will lead us into the fields and hills, to the banks of rivers and lakes, and to the shores of the sea. We can hardly take any country walk, indeed, in which with duly observant eye we may not detect either some geological operation in actual progress, or the evidence of one which was completed long ago. Having learnt what to look for and how to interpret it when seen, we are as it were gifted with a new sense. Every landscape comes to possess a fresh interest and charm, for we carry about with us everywhere an added power of enjoyment, whether the scenery has long been familiar or presents itself for the first time. I would therefore seek to impress the main object, to foster a habit of observation, rather than merely to relate what has been seen and determined by others. If they will so learn these lessons, I feel sure that they will never regret the time and labor they may spend over the task.

THE GEOLOGICAL STRATA.

The strata composing the earth's crust are divided by most geologists into two great classes: 1. Those generally attributed to the agency of water. 2. To the action of fire; which may be subdivided as follows: (a) Aqueous formations, stratified, rarely crystalline (sedimentary or fossiliferous rocks; metamorphic or unfossiliferous). (b) Igneous formations, unstratified, crystalline (volcanic, as basalt; plutonic, as granite).

The geological record is classified into five main divisions or periods: 1. The Archæan, lifeless and dawn of life. 2. The Palæozoic (ancient life). 3. The Mesozoic (middle life). 4. The Cenozoic (recent life). 5. Quaternary, the age in which man's first appearance is indicated.

Periods		Eras		Series	Subdivisions
Quaternary Period	Age of Primeval Man	Quaternary or Post Tertiary		3. Recent 2. Champlain 1. Glacial	Pleistocene
Cenozoic Period	Age of Mammals	Tertiary Era		4. Pliocene 3. Miocene 2. Oligocene 1. Eocene	English Crag Upper Molasse Rupelian and Tongrian of Belgium
Mesozoic Period	Age of Reptiles	Cretaceous Era		4. Laramie 3. Colorado 2. Dakota 1. Lower	Upper Chalk Lower Chalk. Chalk Marl Gault Neocomian. Lower Greensand
		Jura-Trias	Jurassic	3. Purbeck 2. Oolite 1. Lias	Wealden Purbeck. Portland. Kimmeridge Oxford Oolites. Lower or Bath Oolite 1. Lower Lias. 2. Marlstone. 3. Upper Lias
			7. Triassic	4. Rhætic 3. Upper 2. Middle 1. Lower	Kossen beds, Dachstein beds; Alpine Keuper [Trias, in part Muschelkalk Bunter-Sandstein
				Carboniferous Era	3. Permian 2. Carboniferous 1. Subcarboniferous
Palæozoic Period	Age of Coal Plants	Carboniferous Era		3. Permian 2. Carboniferous 1. Subcarboniferous	2. Magnesian Limestone 1. Lower Red Sandstone, or Rothliegendes 3. Upper Coal-Measures 2. Lower Coal-Measures 1. Millstone Grit Lower Carboniferous. Mountain Limestone
	Age of Fishes	Devonian Era		5. Catskill and Chemung 4. Portage 3. Hamilton 2. Coniferous 1. Oriskany	Catskill Red Sandstone Chemung Portage Genesee Slate Hamilton Beds Marcellus Shale Upper Helderberg Schoharie Grit Oriskany Sandstone } Old Red Sandstone
	Age of Invertebrates	Upper Silurian		3. Lower Helderberg 2. Onondaga 1. Niagara	Lower Helderberg Onondaga Salt Group. Salina beds. Water Lime 3. Niagara Group. Wenlock Group 2. Clinton Group } Upper 1. Medina Sandstone } Llandovery
		Lower Silurian		3. Trenton 2. Chazy 1. Calciferous	3. Hudson River beds. Cincinnati Group. Lower Llandovery 2. Utica Shales 1. Trenton Limestone. Caradoc and Bala Limestone Black River Limestone Chazy Limestone Calciferous Sandrock. Magnesian stone
		Cambrian			Lower, Middle, and Upper Cambrian
Archæan Period		Eozoic (dawn) of life Azoic (lifeless)			1. Laurentian. Huronian

PREHISTORIC TIMES.

BY

SIR JOHN LUBBOCK (LORD AVEBURY).

THE first appearance of man in Europe dates from a period so remote, that neither history nor tradition can throw any light on his origin or mode of life. Under these circumstances, some have supposed that the past is hidden from the present by a veil, which time will probably thicken, but never can remove. Thus our prehistoric antiquities have been valued as monuments of ancient skill and perseverance, not regarded as pages of ancient history; recognized as interesting vignettes, not as historical pictures. Some writers have assured us, that, in the words of Palgrave, "We must give it up, that speechless past; whether fact or chronology, doctrine or mythology; whether in Europe, Asia, Africa, or America; at Thebes or Palenque, on Lycian shore or Salisbury Plain; lost is lost; gone is gone forever." Others have taken a more hopeful view, but in attempting to reconstruct the story of the past, they have too often allowed imagination to usurp the place of research, and have written in the spirit of the novelist, rather than in that of the philosopher.

Of late years, however, a new branch of knowledge has arisen; a new Science has, so to say, been born among us, which deals with times and events far more ancient than any which have yet fallen within the province of the archæologist. The geologist reckons not by days or by years; the whole six thousand years, which were until lately looked on as the sum of the world's existence, are to him but one unit of measurement in the long succession of past ages. Our knowledge of geology is, of course, very incomplete; on some questions we shall no doubt see reason to change our opinion, but, on the whole, the conclusions to which it points are as definite as those of zoology, chemistry, or any of the kindred sciences. Nor

does there appear to be any reason why those methods of examination which have proved so successful in geology, should not also be used to throw light on the history of man in prehistoric times. Archæology forms, in fact, the link between geology and history. It is true that in the case of other animals we can, from their bones and teeth, form a definite idea of their habits and mode of life, while in the present state of our knowledge the skeleton of a savage could not always be distinguished from that of a philosopher. But on the other hand, while other animals leave only teeth and bones behind them, the men of past ages are to be studied principally by their works: houses for the living, tombs for the dead, fortifications for defence, temples for worship, implements for use, and ornaments for decoration.

From the careful study of the remains which have come down to us, it would appear that Prehistoric Archæology may be divided into four great epochs.

I. That of the Drift; when man shared the possession of Europe with the Mammoth, the Cave Bear, the Woolly-haired Rhinoceros, and other extinct animals. This I have proposed to call the “Palæolithic” period.

II. The later or polished Stone Age; a period characterized by beautiful weapons and instruments made of flint and other kinds of stone; in which, however, we find no trace of the knowledge of any metal, excepting gold, which seems to have been sometimes used for ornaments. For this period I have suggested the term “Neolithic.”

III. The Bronze Age, in which bronze was used for arms and cutting instruments of all kinds.

IV. The Iron Age, in which that metal had superseded bronze for arms, axes, knives, etc.; bronze, however, still being in common use for ornaments, and frequently also for the handles of swords and other arms, though never for the blades.

Stone weapons, however, of many kinds were still in use during the Age of Bronze, and lingered on even into that of Iron, so that the mere presence of a few stone implements is not in itself sufficient evidence that any given

“find” belongs to the Stone Age. In order to prevent misapprehension, it may also be well to state, at once, that, for the present, I only apply this classification to Europe, though, in all probability, it might be extended also to the neighboring regions in Asia and Africa. The civilization of the south of Europe, moreover, preceded that of northern Europe. As regards other civilized countries, China and Japan for instance, we, as yet, know but little of their prehistoric archæology, though recent researches have gone far to prove that the use of iron was there also preceded by bronze, and bronze by stone. Some nations, indeed, such as the Fuegians, Andamaners, etc., are even now, or were lately, in an Age of Stone.

It is probable that gold was the metal which first attracted the attention of man; it is found in many rivers, and by its bright color would certainly strike even the rudest savages, who are known to be very fond of personal decoration. Silver does not appear to have been discovered until long after gold, and was apparently preceded by both copper and tin; for it rarely, if ever, occurs in tumuli of the Bronze Age; but however this may be, copper seems to have been the metal which first became of real importance to Man; no doubt owing to the fact that its ores are abundant in many countries, and can be smelted without difficulty; and that, while iron is hardly ever found except in the form of ore, copper often occurs in a native condition, and can be beaten at once into shape. Thus, for instance, the North American Indians obtained pure copper from the mines near Lake Superior and elsewhere, and hammered it at once into axes, bracelets, and other objects.

Tin also early attracted notice, probably on account of its great heaviness. When metals were very scarce, it would naturally sometimes happen that, in order to make up the necessary quantity some tin would be added to copper, or vice versâ. It would then be found that the properties of the alloy were quite different from those of either metal, and a very few experiments would determine the most advantageous proportion, which for axes and other cutting instruments is about nine parts of cop-

per to one of tin. No implements or weapons of tin have yet been found, and those of copper are extremely rare in Western Europe, whence it has been inferred that the art of making bronze was known elsewhere before the use of either copper or tin was introduced into Europe. Many of the so-called "copper" axes, etc., contain a small proportion of tin; and the few exceptions indicate probably a mere temporary want, rather than a total ignorance, of this metal.

The ores of iron, though more abundant, are much less striking in appearance than those of copper. Moreover, though they are perhaps more easily reduced, the metal, when obtained, is much less tractable than bronze. This valuable alloy can very easily be cast, and, in fact, all the weapons and implements made of it in olden times were cast in moulds of sand or stone. The art of casting iron, on the other hand, was unknown, until a comparatively late period.

In the writings of the early poets, iron is frequently characterized by an epithet and its adjective which were used metaphorically to imply the greatest stubbornness.

These considerations tend very much to remove the *à priori* improbability that a compound and comparatively expensive material like bronze should have been in general use before such a common metal as iron, and the evidence that it was so seems conclusive.

Hesiod, who is supposed to have written about 900 B.C., and who is the earliest European author whose works have come down to us, appears to have lived during the transition between the Bronze and Iron Ages. He distinctly states that iron was discovered later than copper and tin. Speaking of those who were ancient, even in his day, he says that they used bronze, and not iron. . . . It is significant that the Greek word from which bronze is derived means to work in metal. Moreover, the forms of early weapons indicate that those of iron were copied from bronze, not those of bronze from iron. Hesiod's poems, as well as those of Homer, show that nearly three thousand years ago the value of iron was known and appreciated. It is true, as we read in Dr. Smith's Dictionary

of Greek and Roman Antiquities, bronze “is represented in the Iliad and Odyssey as the common material of arms, instruments, and vessels of various sorts; the latter [iron] is mentioned much more rarely.” While, however, the above statement is strictly correct, we must remember that among the Greeks the word iron was used, even in the time of Homer, as synonymous with a sword. . . .

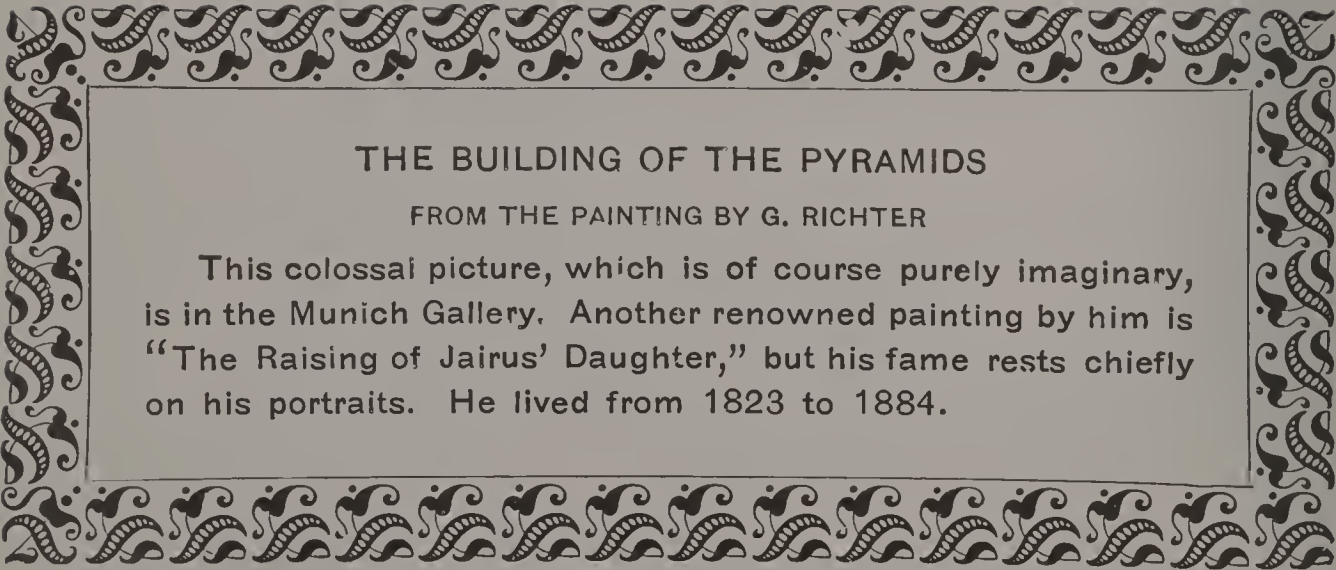
Coming down to more modern times, Eccard in 1750 and Goguet in 1758 mention the three latter ages in plain terms; the same idea runs through Borlase’s “History of Cornwall,” and Sir Richard Colt Hoare also alludes to “instruments of stone before the use of metals was known” and expresses the opinion that instruments of iron “denote a much later period” than those of bronze.

To the Northern archæologists, however—especially to Mr. Thomsen, the founder of the Museum at Copenhagen, and to Professor Nilsson—must be ascribed the merit of having raised these suggestions to the rank of a scientific classification.

Copper and tin were perhaps discovered in Central Asia. The earliest evidence of their use is in Egypt. Neither of them, however, occurs in that country, though the copper mines of Mount Sinai were worked by King Dyezer of the 3d Dynasty, about 4000 B.C., and small implements of bronze occur in the tombs of Abydos, El Amreh, etc., which are referred to an even earlier period. The museum of Gizeh contains an admirable bronze statue of Pepi I., who is supposed to have reigned about 3400 B.C. It seems probable that the use of metal was not discovered in Egypt, but that the Pharaonic Egyptians brought the knowledge of metals with them from the East.

As regards iron, Mr. Budge informs me that in a passage in the funeral text of Pepi I., about B.C. 3400, it is said that this king will sit upon a “throne of iron ornamented with lions’ faces,” and the hoofs of the bull Sma-ur, and in several places in the texts of this period there is abundant reference to iron. Thus the abode of the blessed was in heaven, the floor of which was made of





THE BUILDING OF THE PYRAMIDS

FROM THE PAINTING BY G. RICHTER

This colossal picture, which is of course purely imaginary, is in the Munich Gallery. Another renowned painting by him is "The Raising of Jairus' Daughter," but his fame rests chiefly on his portraits. He lived from 1823 to 1884.

iron, and the Nile flowed across it. The earth below was lit by night either by lamps being suspended from holes which had been bored in it, or by the light which made its way through the holes. The recensions of these texts which we now have cannot have been made after B.C. 3800, and in his opinion they are much earlier.

There is a prayer in the Harris papyrus, written during the reign of Rameses III. (1300 B.C.), that the words of the king may be "firm as iron." In the same papyrus, vessels of iron are mentioned, and the king is said to have made the wall of the temple of Horus like a "hill of iron." Objects of iron are also mentioned in the Karnac tribute. In the lists of Thothmes III. (1600 B.C.) iron comes third in the series of metals paid as tribute. These references, however, imply that the use of iron was already well known. This renders less improbable the authenticity of the piece of iron said to have been found wedged in between two of the stones of the Great Pyramid. Maspero, moreover, in 1882 found some pieces of iron in the Black Pyramid of Abousir (6th Dynasty); but no iron has been found in any of the tombs belonging to the earlier Egyptian dynasties.

The earliest evidence of iron in Assyria is an inscription of Tiglath-Pileser (1120 B.C.), who says: "In the desert of Mitani near Araziki, which is in front of the land of Hatti, I slew four mighty buffaloes with my great bow and iron arrows, and with my lance."

In China copper is said to have been used as far back as the reign of Yu Nai Hwang-ti, 2200 B.C.; and iron in that of Kung Kiu, about 1900 B.C. Copper axes of very simple type have also been discovered in India, but we have no means of determining their date.

The remarkable phase of archaic culture known as Mycenæan—when arms of bronze were beautifully inlaid with gold, when gems were cut, and the potter's art had attained a high degree of perfection—appears to have attained its zenith about 1500 B.C. It must therefore have commenced much earlier.

The date of the introduction of iron into the North of Europe cannot at present be satisfactorily determined;

nevertheless it is most likely that the use of this metal spread rapidly. Not only does it seem *à priori* probable that such an important discovery would have done so, but it is evident that the same commercial organization which had already carried the tin of Cornwall all over the continent, would equally facilitate the transmission of iron. However this may be, the soldiers of Brennus were provided with iron swords, and when the armies of Rome brought the civilization of the South into contact with that of the North, they found iron already well known to, and in general use among, their new enemies. Nor is there any reason to suppose that arms of bronze were also at that time still in use in the North, for, had this been so, they would certainly have been mentioned by the Roman writers; whereas the description given by Tacitus of the Caledonian weapons shows that in his time the swords used in Scotland were made of iron. Moreover there are several cases in which large quantities of arms belonging to the Roman period have been found together, and in which the arms and implements are all of iron. This argument is in its very nature cumulative, and cannot, therefore, be fully developed here, but out of many, I will mention a few cases in illustration.

Some years ago, an old battlefield was discovered at Tiefenau, near Berne, and described by M. Jahn. On it were found a great number of objects made of iron, such as fragments of chariots, bits for horses, wheels, pieces of coats of mail, and arms of various sorts, including no less than a hundred two-handed swords. All of these were made of iron, but with them were several fibulæ of bronze, and some coins, of which about thirty were of bronze, struck at Marseilles, and presenting a head of Apollo on one side and a bull on the other; both good specimens of Greek art. The rest were silver pieces, also struck at Marseilles. These coins, and the absence of any trace of Roman influence, sufficiently indicate the antiquity of these interesting remains.

A very similar collection of antiquities has been obtained from the ancient lake-village near La Tene, on the Lake of Neufchâtel.

Some very interesting “finds” of articles belonging to the Iron Age have been made in the peat bogs of Slesvick, and described by M. Engelhardt, Curator of the Museum at Flensborg. One of these, in the Moss of Nydam, comprises clothes, sandals, brooches, tweezers, beads, helmets, shields, shield bosses, breast-plates, coats of mail, buckles, sword-belts, sword-sheaths, 100 swords, 500 spears, 30 axes, 40 awls, 160 arrows, 80 knives, various articles of horse gear, wooden rakes, mallets, vessels, wheels, pottery, coins, etc. Without a single exception, all the weapons and cutting implements are made of iron, though bronze was freely used for brooches and other similar articles.

In the summer of 1862, M. Engelhardt found in the same field a ship, or rather a large flat-bottomed boat, seventy feet in length, three feet in the middle, and eight or nine feet wide. The sides are of oak boards, overlapping one another, and fastened together by iron bolts. On the inner side of each board are several projections, which are not made from separate pieces, but were left when the boards were cut out of the solid timber. Each of these projections has two small holes, through which ropes, made of the inner bark of trees, were passed, in order to fasten the sides of the boat to the ribs. The rowlocks are formed by a projecting horn of wood, under which is an orifice, so that a rope, fastened to the horn and passing through the orifice, leaves a space through which the oar played. There appear to have been about fifty pairs of oars, of which sixteen have already been discovered. The bottom of the boat was covered by matting. I visited the spot about a week after the boat had been discovered, but was unable to see much of it, as it had been taken to pieces, and the boards, etc., were covered over with straw and peat, that they might dry slowly. In this manner, M. Engelhardt hoped that they would perhaps, at least in part, retain their original shape. The freight of the boat consisted of iron axes, including a socketed celt with its handle, swords, lances, knives, brooches, whetstones, wooden vessels, and oddly enough, two birch brooms, with many smaller articles.

Only those, however, have yet been found which remained actually in the boat; and, as in sinking, it turned partly over on its side, no doubt many more articles will reward further explorations. It is evident that this ancient boat was sunk on purpose, because there is a square hole about six inches in diameter hewn out of the bottom; and it has been suggested that these objects were sunk as offerings to the Lake, but, on the whole, it seems more probable that in some time of panic or danger the objects contained in it were thus hidden by their owner, who was never able to recover them. Even in recent times of disturbance, as, for instance, in the beginning of the last century, and in 1848, many arms, ornaments, household utensils, etc., were so effectually hidden in the lakes and peat mosses, that they could never be found again. Much interest is added to this vessel and its contents, by the fact that we can fix almost their exact date. The boat lies, as I have already mentioned, within a few yards of the spot where the previous discoveries of Nydam were made, and as all the arms and ornaments exactly correspond, there can be little doubt that they belong to the same period. Now, the previous collection included nearly fifty Roman coins, ranging in date from A.D. 67 to A.D. 217, and we cannot, therefore, be far wrong in referring these remains to the third century.

A very similar discovery has been made at Thorsberg in the same neighborhood, but in this case, owing to some chemical difference in the peat, the iron has been almost entirely removed. It may naturally be asked why, then, this should be quoted as an instance of the Iron Age? And the answer seems quite satisfactory. All the swords, lance-heads, and axe-blades have disappeared, while the handles of bronze or wood are perfectly preserved, and as the ornaments and other objects of bronze are well preserved, it is evident that the swords, etc., were not of that metal; and it is therefore reasonable to conclude that they were of iron, more especially as the whole character of the objects resembles that of those found at Nydam, and the coins, which are about as numerous as those from the latter place, range from 60 A.D. to 197 A.D.; so that

these two great "finds" may be regarded as almost contemporaneous.

MAN, ANCIENT AND MODERN.

BY

EDWARD B. TYLOR.

THE student who seeks to understand how mankind came to be as they are, and to live as they do, ought first to know clearly whether men are newcomers on the earth, or old inhabitants. Did they appear with their various races and ways of life ready-made, or were these shaped by the long, slow growth of ages? In order to answer this question, our first business will be to take a rapid survey of the varieties of men, their languages, their civilization, and their ancient relics, to see what proofs may thus be had of man's age in the world. The outline sketch thus drawn will also be useful as an introduction to the fuller examination of man and his ways of life.

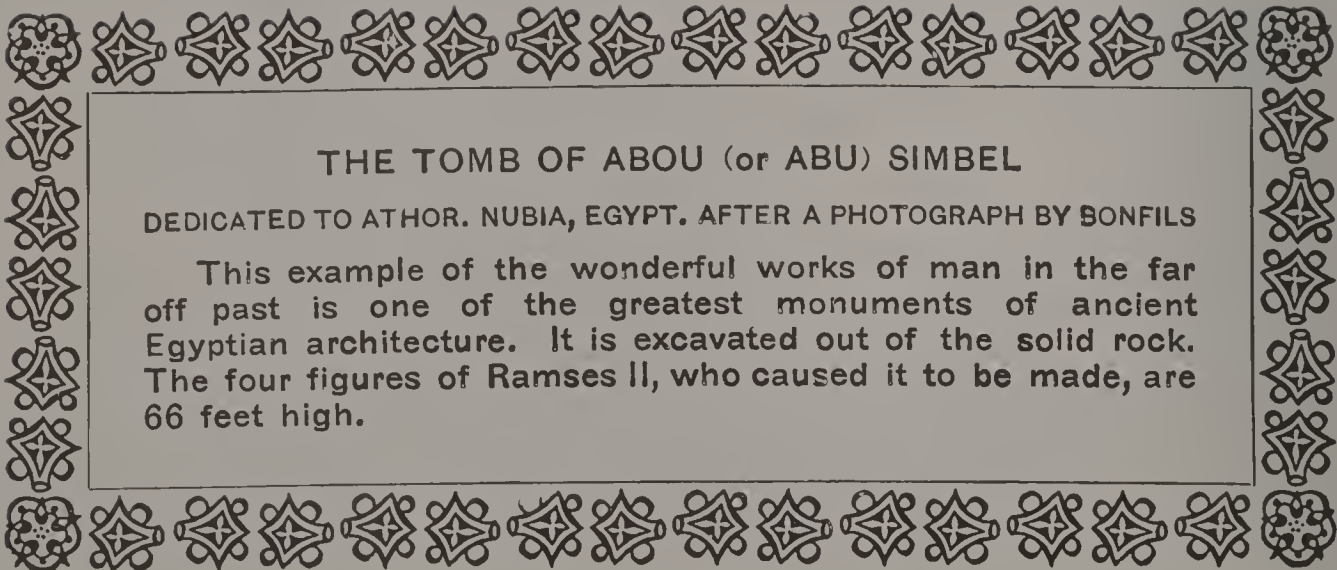
First, as to the varieties of mankind. Let us suppose ourselves standing at the docks in Liverpool or London, looking at groups of men of races most different from our own. There is the familiar figure of the African negro, with skin so dark-brown as to be popularly called black, and black hair so naturally frizzed as to be called woolly. Nor are these the only points in which he is unlike us. Indeed, the white men who blacken their faces and frizz their hair to look like negroes make a very poor imitation, for the negro features are quite distinct; we well know the flat nose, wide nostrils, thick protruding lips, and, when the face is seen in profile, the remarkable projecting jaws. A hatter would at once notice that the negro's head is narrower in proportion than the usual oval of the hats made for Englishmen. It would be possible to tell a negro from a white man even in the dark by the peculiar satiny feel of his skin, and the yet more

From "Anthropology, an introduction to the study of man and civilization."

peculiar smell which no one who has noticed it is ever likely to mistake. In the same docks, among the crews of Eastern steamers, we observe other well-marked types of man. The Coolie of South India (who is not of Hindu race, but belongs to the so-called hill-tribes) is dark-brown of skin, with black, silky, wavy hair, and a face wide-nosed, heavy-jawed, fleshy-lipped. More familiar is the Chinese, whom the observer marks down by his less than European stature, his jaundice-yellow skin, and coarse, straight black hair; the special character of his features is neatly touched off on his native china-plates and paper-screens, which show the snub nose, high cheek-bones, and that curious slanting set of the eyes which we can imitate by putting a finger near the outer corners of our own eyes and pushing upward. By comparing such a set of races with our own countrymen, we are able to make out the utmost differences of complexion and feature among mankind. While doing so, it is plain that white men, as we agree to call ourselves, show at least two main race-types. Going on board a merchant-ship from Copenhagen, we find the crew mostly blue-eyed men of fair complexion and hair, a remarkable contrast to the Genoese vessel moored alongside, whose sailors show almost to a man swarthy complexions and lustrous black eyes and hair. These two types of man have been well described as the fair-whites and the dark-whites.

It is only within modern times that the distinctions among races have been worked out by scientific methods. Yet since early ages, race has attracted notice from its connection with the political questions of countryman or foreigner, conqueror or conquered, freeman or slave, and in consequence its marks have been watched with jealous accuracy. In the Southern United States, till slavery was done away a few years ago, the traces of negro descent were noted with the utmost nicety. Not only were the mixed breeds regularly classed as mulattoes, quadroons, and down to octaroons, but even where the mixture was so slight that the untrained eye noticed nothing beyond a brunette complexion, the intruder who had ventured to sit down at a public dinner table was called upon to show





THE TOMB OF ABOU (or ABU) SIMBEL

DEDICATED TO ATHOR. NUBIA, EGYPT. AFTER A PHOTOGRAPH BY BONFILS

This example of the wonderful works of man in the far off past is one of the greatest monuments of ancient Egyptian architecture. It is excavated out of the solid rock. The four figures of Ramses II, who caused it to be made, are 66 feet high.

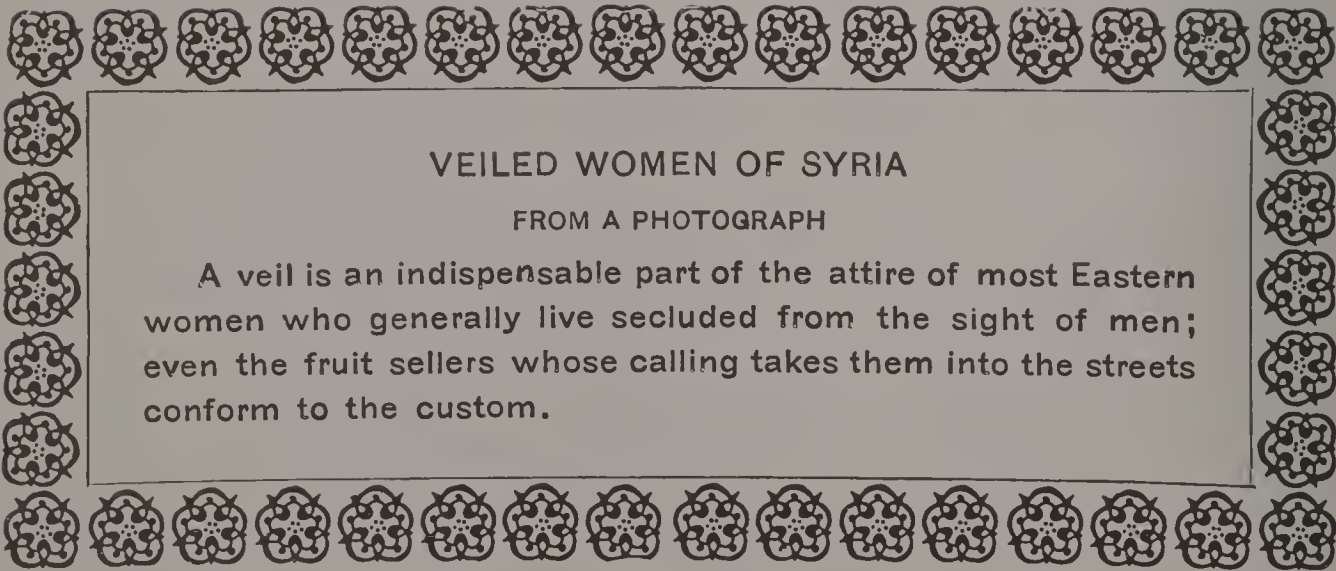
his hands, and the African taint detected by the dark tinge at the root of the finger-nails.

Seeing how striking the broad distinctions of race are, it was to be expected that ancient inscriptions and figures should give some view of the races of man as they were at the beginning of historical times. It is so in Egypt, where the oldest writings of the world appear. More than 4,000 years ago we begin to find figures of the Egyptians themselves, in features much the same as in later times. In the sixth dynasty, about 2,000 B.C., the celebrated inscription of Prince Una makes mention of the *Nahsi*, or negroes, who were levied and drilled by ten thousands for the Egyptian army. Under the twelfth dynasty, on the walls of the tomb of Knumhetp, there is represented a procession of *Amu*, who are seen by their features to be of the race to which Syrians and Hebrews belonged. Especially the wall-paintings of the tombs of the kings of Thebes, of the nineteenth dynasty, have preserved colored portraits of the four great races distinguished by the Egyptians. These are the red-brown Egyptians themselves, the people of Palestine with their aquiline profile and brownish complexion, the flat-nosed, thick-lipped African negroes, and the fair-skinned Libyans. Thus mankind was already divided into well-marked races, distinguished by color and features. It is surprising to notice how these old-world types of man are still to be recognized. The Ethiopian of the ancient monuments can at this day be closely matched. Notwithstanding the many foreign invasions of Egypt, the mass of the village population is true-bred enough for men to be easily picked out as representatives of the times of the Pharaohs. Their portraits have only to be drawn in the stiff style of the monuments, with the eye conventionally shown full-front in the profile face, and we have before us the very Egyptians as they depicted themselves in the old days when they held the Israelites in bondage. In the same way the ancient Egyptian portraits of captives from Palestine, whether Syrians, Phœnicians, or Hebrews, show the strongly-marked Israelite type of features to be seen at this day in every city of Europe. Alto-

gether, the evidence of ancient monuments, geography and history, goes to prove that the great race-divisions of mankind are of no recent growth, but were already settled before the beginning of the historical period. Since then their changes seem to have been comparatively slight, except in the forming of mixed races by inter-marriage.

Hence it follows that the historic ages are to be looked on as but the modern period of man's life on earth. Behind them lies the prehistoric period, when the chief work was done of forming and spreading over the world the races of mankind. Though there is no scale to measure the length of this period by, there are substantial reasons for taking it as a long stretch of time. Looking at an ethnological map, colored to show what race of men inhabits each region, it is plain at a glance that the world was not peopled by mere chance scattering of nations, a white tribe here and a brown tribe there, with perhaps a black tribe in between. Far from this, whole races are spread over vast regions as though they grew there, and the peculiar type of the race seems more or less connected with the climate it lives in. Especially it is seen that the mass of black races belong to the equatorial regions in Africa and the Eastern Archipelago, the yellow race to Central and Southern Asia, the white race to temperate Asia and Europe. Some guess may even be made from the map which district was the primitive centre where each of these races took shape, and whence it spread far and wide. Now if, as some have thought, the Negroes, Mongolians, Whites, and other races, were distinct species, each sprung from a separate origin in its own region, then the peopling of the globe might require only a moderate time, the races having only to spread each from its own birthplace. But the opinion of modern zoologists, whose study of the species and breeds of animals makes them the best judges, is against this view of several origins of man, for two principal reasons. First, that all tribes of men, from the blackest to the whitest, the most savage to the most cultured, have such general likeness in the structure of their bodies and





VEILED WOMEN OF SYRIA

FROM A PHOTOGRAPH

A veil is an indispensable part of the attire of most Eastern women who generally live secluded from the sight of men; even the fruit sellers whose calling takes them into the streets conform to the custom.

the working of their minds, as is easiest and best accounted for by their being descended from a common ancestry, however distant. Second, that all the human races, notwithstanding their form and color, appear capable of freely intermarrying and forming crossed races of every combination, such as the millions of mulattoes and mestizos sprung in the New World from the mixture of Europeans, Africans, and native Americans; this again points to a common ancestry of all the races of man. We may accept the theory of the unity of mankind as best agreeing with ordinary experience and scientific research. As yet, however, the means are very imperfect of judging what man's progenitors were like in body and mind, in times before the forefathers of the present Negroes, and Tatars, and Australians, had become separated into distinct stocks. Nor is it yet clear by what causes these stocks or races passed into their different types of skull and limbs, of complexion and hair. It cannot be at present made out how far the peculiarities of single ancestors were inherited by their descendants and became stronger by inbreeding; how far, when the weak and dull-witted tribes failed in the struggle for land and life, the stronger, braver, and abler tribes survived to leave their types stamped on the nations sprung from them; how far whole migrating tribes underwent bodily alteration through change of climate, food, and habits, so that the peopling of the earth went on together with the growth of fresh races fitted for life in its various regions. Whatever share these causes and others yet more obscure may have had in varying the races of man, it must not be supposed that such differences as between an Englishman and a Gold Coast negro are due to slight variations of breed. On the contrary, they are of such zoological importance as to have been compared with the differences between animals which naturalists reckon distinct species, as between the brown bear with its rounded forehead, and the polar bear with its whitish fur and long flattened skull. If then we are to go back in thought to a time when the ancestors of the African, the Australian, the Mongol, and the Scandinavian, were as yet one undi-

vided stock, the theory of their common descent must be so framed as to allow causes strong enough and time long enough to bring about changes far beyond any known to have taken place during historical ages. Looked at in this way, the black, brown, yellow, and white men whom we have supposed ourselves examining on the quays, are living records of the remote past, every Chinese and Negro bearing in his face evidence of the antiquity of man.

Next, what has language to tell of man's age on the earth? It appears that the distinct languages known number about a thousand. It is clear, however, at the first glance that these did not all spring up separately. There are groups of languages which show such close likeness in their grammars and dictionaries as proves each group to be descended from one ancestral tongue. Such a group is called a family of languages, and one of the best known of such families may be taken as an example of their way of growth. In ancient times Latin (using the word in a rather wide sense) was the language of Rome and other Italian districts, and with the spread of the Roman empire it was carried far and wide, so as to oust the early languages of whole provinces. Undergoing in each land a different course of change, Latin gave rise to the Romance family of languages, of which Italian, Spanish, and French are well-known members. How these languages have come to differ after ages of separate life, we judge by seeing that sailors from Dieppe cannot make themselves understood in Malaga, nor does a knowledge of French enable us to read Dante. Yet the Romance languages keep the traces of their Roman origin plainly enough for Italian, Spanish, and French sentences to be taken and every word referred to something near it in classical Latin, which may be roughly treated as the original form. Familiar proverbs are here given as illustrations, with the warning to the reader that, for convenience' sake, the comparisons are not all carried out in precise grammatical form.

ITALIAN.

E meglio un uovo oggi che una gallina domani.
est melius unum ovum hodie quid una gallina de mane.
i.e. Better is an egg to-day than a hen to-morrow.

Chi va piano va sano, chi va sano va lontano.
qui vadit planum vadit sanum, qui vadit sanum vadit longum.
i.e. He who goes gently goes safe, he who goes safe goes far.

SPANISH.

Quien canta sus males espanta.
quem cantat suos malos expav(ere).
i.e. He who sings frightens away his ills.

Por la calle de despues se va á la casa de nunca.
per illam callem de de-ex-post se vadit ad illam casam de nunquam.
i.e. By the street of by and by one goes to the house of never.

FRENCH.

Un tiens vaut mieux que deux tu l'auras.
unum tene valet melius quod duos tu illum habere-habes.
i.e. One take-it is worth more than two thou-shalt-have-its.

Parler de la corde dans la maison d'un pendu.
parabola de illam chordam de intus illam mansionem de unum pend(o).
i.e. (Never to) talk of a rope in the house of a hanged man.

It is plain on the face of such sentences as these, that Italian, Spanish, and French are in fact transformed Latin, their words having been gradually altered as they descended, generation after generation, from the parent tongue. Now even if Latin were lost, philologists would still be able, by comparing the set of Romance languages, to infer that such a language must have existed to give rise to them all, though no doubt such a reconstruction of Latin would give but a meagre notion, either of its stock of words or its grammatic inflections. This kind of argument by which a lost parent-language is discovered from the likeness among its descendants, may be well seen in another set of European tongues. Let us suppose ourselves listening to a group of Dutch sailors; at first their talk may seem unintelligible, but after a while a sharp ear will catch the sound of well-known words, and perhaps at last whole sentences like these:—*Kom hier! Wat zegt*

gij? Hoe is het weder? Het is een hevige storm, ik ben zeer koud. Is de maan op? Ik weet niet. The spelling of these words, different from our mode, disguises their resemblance, but as spoken they come very near corresponding sentences in English, somewhat old-fashioned or provincial, thus:—*Come here! What say ye? How is the weather? It is a heavy storm, I be sore cold. Is the moon up? I wit not.* Now it stands to reason that no two languages could have come to be so like, unless both were descended from one parent tongue. The argument is really much like that as to the origin of the people themselves. As we say, these Dutch and English are beings so nearly alike that they must have descended from a common stock, so we say, these languages are so like that they must have been derived from a common language. Dutch and English are accordingly said to be closely related to one another, and the language of Friesland proves on examination to be another near relative. Thence it is inferred that a parent language or group of dialects, which may be called the original Low-Dutch, or Low-German, must once have been spoken, though it is not actually to be found, not happening to have been written down and so preserved.

Now it is easy to see that as ages go on, and the languages of a family each take their separate course of change, it must become less and less possible to show their relationship by comparing whole sentences. Philologists have to depend on less perfect resemblances, but such are sufficient when not only words from the dictionary correspond in the two languages, but also these are worked up into actual speech by corresponding forms of grammar. Thus when Sanskrit, the ancient language of the Brahmans in India, is compared with Greek and Latin, it appears that the Sanskrit verb *dâ* expresses the idea to give, and makes its present tense by reduplicating and adding a person-affix, so becoming *dadâmi*, nearly as Greek makes *didōmi*; from the same root Sanskrit makes a future participle *dâsyamânas*, corresponding to Greek *dōsomenos*, while Sanskrit *dâtâr* matches Greek *dotēr*=giver. So where Latin has *vox, vocis, vocem, voces, vocum*,

vocibus, Sanskrit has *vâk*, *vâcas*, *vâcam*, *vâcas*, *vâcâm*, *vâgbhyas*. When such thoroughgoing analogy as this is found to run through several languages, as Sanskrit, Greek, and Latin, no other explanation is possible but that an ancient parent language gave rise to them all, they having only varied off from it in different directions. In this way it is shown that not only are these particular languages related by descent, but that groups of ancient and modern languages in Asia and Europe, the Indian group, the Persian group, the Hellenic or Greek group, the Italic or Latin group, the Slavonic group to which Russian belongs, the Teutonic group which English is a member of, the Keltic group which Welsh is a member of, are all descendants of one common ancestral language, which is now theoretically called the Aryan, though practically its nature can only be made out in a vague way by comparing its descendant languages. Some of these have come down to us in forms which are extremely ancient, as antiquity goes in our limited chronology. The sacred books of India and Persia have preserved the Sanskrit and Zend languages, which by their structure show to the eye of the philologist an antiquity beyond that of the earliest Greek and Latin inscriptions and the old Persian cuneiform rock-writing of Darius. But the Aryan languages even in their oldest known states had already become so different that it was the greatest feat of modern philology to demonstrate that they had a common origin at all. The faint likeness by which Welsh still shows its relationship to Greek and German may give some idea of the time that may have elapsed since all three were developed off from the original Aryan tongue, which itself probably ceased to exist long before the historical period began.

Among the languages of ancient nations, another great group holds a high place in the world's history. This is the Semitic family which includes the Hebrew and Phœnician, and the Assyrian deciphered from the wedge-characters of Nineveh. Arabic, the language of the *Koran*, is the great modern representative of the family, and the closeness with which it matches Hebrew may be shown in

familiar phrases. The Arab still salutes the stranger with *salâm alaikum*, "peace upon you," nearly as the ancient Hebrew would have said *shâlôm lâchem*, that is, "peace to you," and the often-heard Arabic exclamation *bismillah* may be turned into Hebrew, as *be-shêm hâ-Elohim*, "in the name of God." So the Hebrew names of persons mentioned in the Bible give the interpretation of many Arabic proper names, as where *Ebed-melech*, "servant of the king," who took Jeremiah out of the dungeon, bore a name nearly like that of the khalif *Abd-el-Melik*, in Mohammedan history. But no one of these Semitic languages has any claim to be the original of the family, standing to the others as Latin does to Italian and French. All of them, Assyrian, Phœnician, Hebrew, Arabic, are sister-languages, pointing back to an earlier parent language which has long disappeared. The ancient Egyptian language of the hieroglyphics cannot be classed as a member of the Semitic family, though it shows points of resemblance which may indicate some remote connection. There are also known to have existed before 2000 B.C. two important languages not belonging to either the Aryan or Semitic family; these were the ancient Babylonian and the ancient Chinese. As for the languages of more outlying regions of the world, such as America, when they come into view they are found likewise to consist of many separate groups or families.

This slight glimpse of the earliest known state of language in the world is enough to teach the interesting lesson that the main work of language-making was done in the ages before history. Going back as far as philology can take us, we find already existing a number of language-groups, differing in words and structure, and if they ever had any relationship with one another no longer showing it by signs clear enough for our skill to make out. Of an original primitive language of mankind, the most patient research has found no traces. The oldest types of language we can reach by working back from known languages show no signs of being primitive tongues of mankind. Indeed, it may be positively asserted that they

are not such, but that ages of growth and decay have mostly obliterated the traces how each particular sound came to express its particular sense. Man, since the historical period, has done little in the way of absolute new creation of language, for the good reason that his wants were already supplied by the words he learnt from his fathers, and all he had to do when a new idea came to him was to work up old words into some new shape. Thus the study of languages gives much the same view of man's antiquity as has been already gained from the study of races. The philologist, asked how long he thinks mankind to have existed, answers that it must have been long enough for human speech to have grown from its earliest beginnings into elaborate languages, and for these in their turn to have developed into families spread far and wide over the world. This immense work had been already accomplished in ages before the earliest inscriptions of Egypt, Babylon, Assyria, Phœnicia, Persia, Greece, for these show the great families of human speech already in full existence.

Next, we have to look at culture or civilization, to see whether this also shows signs of man having lived and labored in ages earlier than the earliest which historical records can tell of. For this purpose it is needful to understand what has been the general course of arts, knowledge, and institutions. It is a good old rule to work from the known to the unknown, and all intelligent people have much to tell from their own experience as to how civilization develops. The account which an old man can give of England as he remembers it in his schoolboy days, and of the inventions and improvements he has seen come in since, is in itself a valuable lesson. Thus, when starting from London by express train to reach Edinburgh by dinner-time, he thinks of when it used to be fair coach-travelling to get through in two days and nights. Catching sight of a signal-post on the line, he remembers how such semaphores (that is, sign-bearers) were then the best means of telegraphing, and stood waving their arms on the hills between London and Plymouth, signalling the Admiralty messages. Thinking of the electric

telegraph which has superseded them, reminds him that this invention arose out of a discovery made in his youth as to the connection between electricity and magnetism. This again suggests other modern scientific discoveries that have opened to us the secrets of the universe, such as the spectrum-analysis which now makes out with such precision the materials of the stars, which is just what our fathers were quite certain no man on earth ever could know. Our informant can tell us, too, how knowledge has not only increased, but is far more widely spread than formerly, when the thriving farmer's son could hardly get schooling practically so good as the laborer's son is now entitled to of right. He may then go on to explain to his hearers how, since his time, the laws of the land have been improved and better carried out, so that men are no longer hanged for stealing, that more is done to reform the criminal classes instead of merely punishing them, that life and property are safer than in old times. Last, but not least, he can show from his own recollection that people are morally a shade better than they were, that public opinion demands a somewhat higher standard of conduct than in past generations, as may be seen in the sharper disapproval that now falls on cheats and drunkards. From such examples of the progress in civilization that has come in a single country and a single lifetime, it is clear that the world has not been standing still with us, but new arts, new thoughts, new institutions, new rules of life, have arisen or been developed out of the older state of things.

Now this growth or development in civilization, so rapid in our own time, appears to have been going on more or less actively since the early ages of man. Proof of this comes to us in several different ways. History, so far as it reaches back, shows arts, sciences, and political institutions beginning in ruder states, and becoming in the course of ages more intelligent, more systematic, more perfectly arranged or organized, to answer their purposes. Not to give many instances of a fact so familiar, the history of parliamentary government begins with the old-world councils of the chiefs and tumultuous as-

semblies of the whole people. The history of medicine goes back to the time when *epilepsy* or "seizure" (Greek *epilepsis*) was thought to be really the act of a demon seizing and convulsing the patient. But our object here is to get beyond such ordinary information of the history books, and to judge what stages civilization passed through in times yet earlier. Here one valuable aid is archæology, which for instance shows us the stone hatchets and other rude instruments which belonged to early tribes of men, thus proving how low their state of arts was. Another useful guide is to be had from survivals in culture. Looking closely into the thoughts, arts, and habits of any nation, the student finds everywhere the remains of older states of things out of which they arose. To take a trivial example, if we want to know why so quaintly cut a garment as the evening dress-coat is worn, the explanation may be found thus. The cutting away at the waist had once the reasonable purpose of preventing the coat skirts from getting in the way in riding, while the pair of useless buttons behind the waist are also relics from the times when such buttons really served the purpose of fastening these skirts behind; the curiously cut collar keeps the now misplaced notches made to allow of its being worn turned up or down, the smart facings represent the ordinary lining, and the sham cuffs now made with a seam round the wrist are survivals from real cuffs when the sleeve used to be turned back. Thus it is seen that the present ceremonial dress-coat owes its peculiarities to being descended from the old-fashioned practical coat in which a man rode and worked. Or again, if one looks in modern English life for proof of the Norman Conquest eight centuries ago, one may find it in the "*Oh yes! Oh yes!*" of the town-crier, who all unknowingly keeps up the old French form of proclamation, "*Oyez! Oyez!*" that is, "Hear ye! Hear ye!" To what yet more distant periods of civilization such survivals may reach back, is well seen in an example from India. There, though people have for ages kindled fire for practical use with the flint and steel, yet the Brahmans, to make the sacred fire for the daily

sacrifice, still use the barbaric art of violently boring a pointed stick into another piece of wood till a spark comes. Asked why they thus waste their labor when they know better, they answer that they do it to get pure and holy fire. But to us it is plain that they are really keeping up by unchanging custom a remnant of the ruder life once led by their remote ancestors. On the whole, these various ways of examining arts and sciences all prove that they never spring forth perfect, like Athene out of the split head of Zeus. They come on by successive steps, and where other information fails, the observer may often trust himself to judge from the mere look of an invention how it probably arose. Thus no one can look at a cross-bow and a common long-bow without being convinced that the long-bow was the earlier, and that the cross-bow was made afterwards by fitting a common bow on a stock, and arranging a trigger to let go the string after taking aim. Though history fails to tell us who did this and when, we feel almost as sure of it as of the known historical facts that the cross-bow led up to the match-lock, and that again to the flint-lock musket, and that again to the percussion musket, and that again to the breech-loading rifle.

Putting these various means of information together, it often becomes possible to picture the whole course of an art or an institution, tracing it back from its highest state in the civilized world till we reach its beginnings in the life of the rudest tribes of men. For instance, let us look at a course of modern mathematics, as represented in the books taken in for university honors. A student living in Queen Elizabeth's time would have had no infinitesimal calculus to study, hardly even algebraic geometry, for what is now called the higher mathematics was invented since then. Going back into the Middle Ages, we come to the time when algebra had been just brought in, a novelty due to the Hindu mathematicians and their scholars, the Arabs; and next we find the numeral ciphers, 0, 1, 2, 3, etc., beginning to be known as an improvement on the old calculating board and the Roman I., II., III. In the classic ages yet earlier, we reach the

time when the methods of Euklid and the other Greek geometers first appeared. So we get back to what was known to the mathematicians of the earliest historical period in Babylonia and Egypt, an arithmetic clumsily doing what children in the lower standards are taught with us to do far more neatly, and a rough geometry consisting of a few rules of practical mensuration. This is as far as history can go toward the beginnings of mathematics, but there are other means of discovering through what lower stages the science arose. The very names still used to denote length, such as cubit, hand, foot, span, nail, show how the art of mensuration had its origin in times when standard measures had not yet been invented, but men put their hands and feet alongside objects of which they wished to estimate the size. So there is abundant evidence that arithmetic came up from counting on the fingers and toes, such as may still be seen among savages. Words still used for numbers in many languages were evidently made during the period when such reckoning on the hands and feet was usual, and they have lasted on ever since. Thus a Malay expresses five by the word *lima*, which (though he does not know it) once meant "hand," so that it is seen to be a survival from ages when his ancestors, wanting a word for five, held up one hand and said "hand." Indeed, the reason of our own decimal notation, why we reckon by tens instead of the more convenient twelves, appears to be that our forefathers got from their own fingers the habit of counting by tens which has been since kept up, an unchanged relic of primitive man. [There are] . . . many other cases of such growth of arts from the simplest origins. Thus, in examining tools, it will be seen how the rudely chipped stone grasped in the hand to hack with, led up to the more artificially shaped stone chisel fitted as a hatchet in a wooden handle, how afterwards when metal came in there was substituted for the stone a bronze or iron blade, till at last was reached the most perfect modern foresters' axe, with its steel blade socketed to take the well-balanced handle. These great moves in the development of the axe, which began before chronol-

ogy and history, have been from the first one of man's chief aids in civilizing himself.

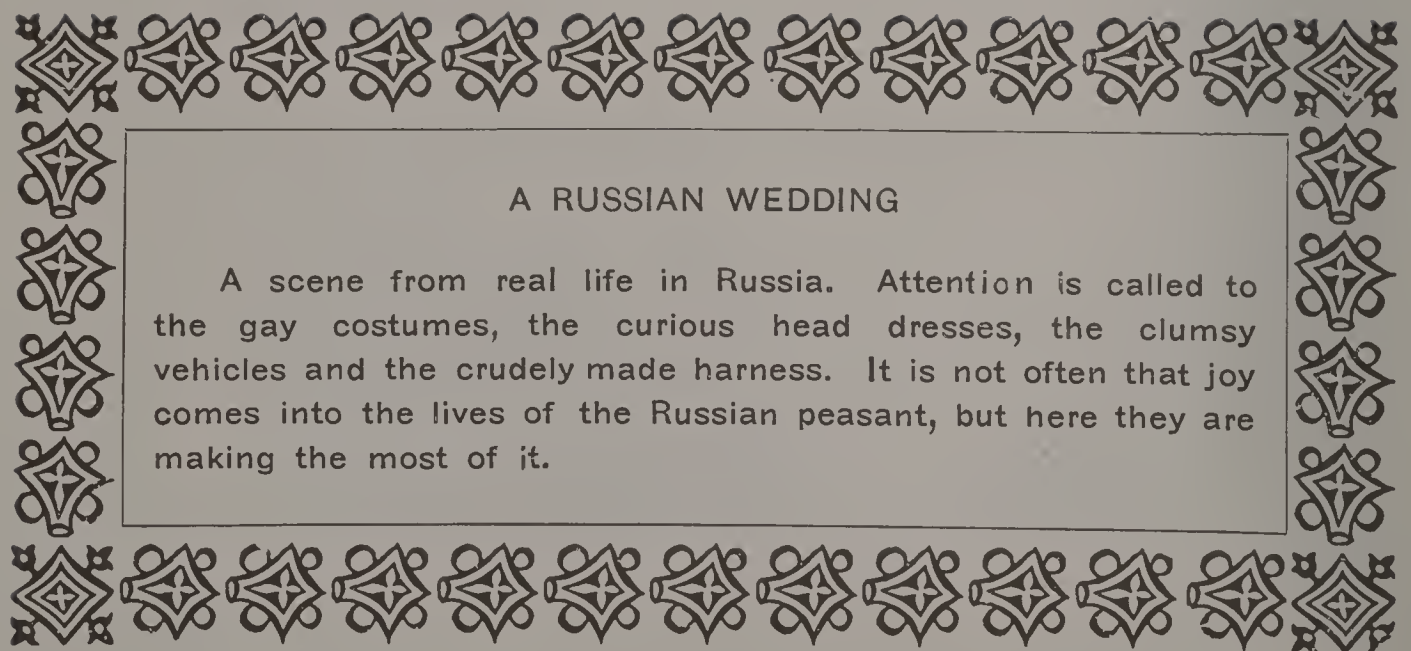
It does not follow from such arguments as these that civilization is always on the move, or that its movement is always progress. On the contrary, history teaches that it remains stationary for long periods, and often falls back. To understand such decline of culture, it must be borne in mind that the highest arts and the most elaborate arrangements of society do not always prevail, in fact they may be too perfect to hold their ground, for people must have what fits with their circumstances. There is an instructive lesson to be learnt from a remark made by an Englishman at Singapore, who noticed with surprise two curious trades flourishing there. One was to buy old English-built ships, cut them down and rig them as junks; the other was to buy English percussion muskets and turn them into old-fashioned flintlocks. At first sight this looks like mere stupidity, but on consideration it is seen to be reasonable enough. It was so difficult to get Eastern sailors to work ships of European rig, that it answered better to provide them with the clumsier craft they were used to; and as for the guns, the hunters far away in the hot, damp forests were better off with gunflints than if they had to carry and keep dry a stock of caps. In both cases, what they wanted was not the highest product of civilization, but something suited to the situation and easiest to be had. Now the same rule applies both to taking in new civilization and keeping up old. When the life of a people is altered by emigration into a new country, or by war and distress at home, or mixture with a lower race, the culture of their forefathers may be no longer needed or possible, and so dwindles away. Such degeneration is to be seen among the descendants of Portuguese in the East Indies, who have intermarried with the natives and fallen out of the march of civilization, so that newly-arrived Europeans go to look at them lounging about their mean hovels in the midst of luxuriant tropical fruits and flowers, as if they had been set there to teach by example how man falls in culture where the need of effort is wanting. Another fre-

quent cause of loss of civilization is when people once more prosperous are ruined or driven from their homes, like those Shoshone Indians who have taken refuge from their enemies, the Blackfeet, in the wilds of the Rocky Mountains, where they now roam, called Digger Indians from the wild roots they dig for as part of their miserable subsistence. Not only the degraded state of such outcasts, but the loss of particular arts by other peoples, may often be explained by loss of culture under unfavorable conditions. For instance, the South Sea Islanders, though not a very rude people when visited by Captain Cook, used only stone hatchets and knives, being indeed so ignorant of metal that they planted the first iron nails they got from the English sailors, in the hope of raising a new crop. Possibly their ancestors never had metals, but it seems as likely that these ancestors were an Asiatic people to whom metal was known, but who, through emigration to ocean islands and separation from their kinsfolk, lost the use of it and fell back into the stone age. It is necessary for the student to be alive to the importance of decline in civilization, but it is here more particularly mentioned in order to point out that it in no way contradicts the theory that civilization itself is developed from low to high stages. One cannot lose a thing without having had it first, and wherever tribes are fallen from the higher civilization of their ancestors, this only leaves it to be accounted for how that higher civilization grew up.

On the whole it appears that wherever there are found elaborate arts, abstruse knowledge, complex institutions, these are results of gradual development from an earlier, simpler, and ruder state of life. No stage of civilization comes into existence spontaneously, but grows or is developed out of the stage before it. This is the great principle which every scholar must lay firm hold of, if he intends to understand either the world he lives in or the history of the past. Let us now see how this bears on the antiquity and early conditions of mankind. The monuments of Egypt and Babylonia show that toward 5,000 years ago certain nations had already come to an ad-

vanced state of culture. No doubt the greater part of the earth was then peopled by barbarians and savages, as it remained afterwards. But in the regions of the Nile and the Euphrates there was civilization. The ancient Egyptians had that greatest mark of a civilized nation, the art of writing; indeed the hieroglyphic characters of their inscriptions appear to have been the origin of our alphabet. They were a nation skilled in agriculture, raising from their fields fertilized by the yearly inundation those rich crops of grain that provided subsistence for the dense population. How numerous and how skilled in constructive art the ancient Egyptians were, is seen by every traveller who looks on the pyramids which have made their name famous through all history. The great pyramid of Gizeh still ranks among the wonders of the world, a mountain of hewn limestone and syenite, whose size Londoners describe by saying that it stands on a square the size of Lincoln's-Inn Fields, and rises above the height of St. Paul's. The perfection of its huge blocks and the beautiful masonry of the inner chambers and passages show the skill not only of the stonecutter but of the practical geometer. The setting of the sides to the cardinal points is so exact as to prove that the Egyptians were excellent observers of the elementary facts of astronomy; the day of the equinox can be taken by observing the sunset across the face of the pyramid, and the neighboring Arabs still adjust their astronomical dates by its shadow. As far back as anything is known of them, the Egyptians appear to have worked in bronze and iron, as well as gold and silver. So their arts and habits, their sculpture and carpentry, their reckoning and measuring, their system of official life with its governors and scribes, their religion with its orders of priesthood and its continual ceremonies, all appear the results of long and gradual growth. What, perhaps, gives the highest idea of antiquity, is to look at very early monuments, such as the tomb of Prince Teta of the 4th dynasty in the British Museum, and notice how Egyptian culture had even then begun to grow stiff and traditional. Art was already reaching the stage when it seemed to men





A RUSSIAN WEDDING

A scene from real life in Russia. Attention is called to the gay costumes, the curious head dresses, the clumsy vehicles and the crudely made harness. It is not often that joy comes into the lives of the Russian peasant, but here they are making the most of it.

that no more progress was possible, for their ancestors had laid down the perfect rule of life, which it was sin to alter by way of reform. Of the early Babylonians or Chaldæans less is known, yet their monuments and inscriptions show how ancient and how high was their civilization. Their writing was in cuneiform or wedge-shaped characters, of which they seem to have been the inventors, and which their successors, the Assyrians, learnt from them. They were great builders of cities, and the bricks inscribed with their kings' names remain as records of their great temples, such, for instance, as that dedicated to the god of Ur, in the city known to Biblical history as Ur of the Chaldees. Written copies of their laws exist, so advanced as to have provisions as to the property of married women, the imprisonment of a father or mother for denying their son, the daily fine of a half-measure of corn levied on the master who killed or ill-used his slaves. Their astrology, which made the names of Chaldæan and Babylonian famous ever since, led them to make those regular observations of the heavenly bodies which gave rise to the science of astronomy. The nation which wrote its name thus largely in the book of civilization, dates back into the same period of high antiquity as the Egyptian. These then are the two nations whose culture is earliest vouched for by inscriptions done at the very time of their ancient grandeur, and, therefore, it is safer to appeal to them than to other nations which can only show as proofs of their antiquity writings drawn up in far later ages. Looking at their ancient civilization, it seems to have been formed by men whose minds worked much like our own. No superhuman powers were required for the work, but just human nature groping on by roundabout ways, reaching great results, yet not half knowing how to profit by them when reached; solving the great problem of writing, yet not seeing how to simplify the clumsy hieroglyphics into letters; devoting earnest thought to religion and yet keeping up a dog and cat worship which was a jest even to the ancients; cultivating astronomy and yet remaining mazed in the follies of astrology. In the midst of their most striking efforts of

civilization, the traces may be discerned of the barbaric condition which prevailed before; the Egyptian pyramids are burial-mounds like those of prehistoric England, but huge in size and built of hewn stone or brick; the Egyptian hieroglyphics, with their pictures of men and beasts and miscellaneous things, tell the story of their own invention, how they began as a mere picture-writing like that of the rude hunters of America. Thus it appears that civilization, at the earliest dates where history brings it into view, had already reached a level which can only be accounted for by growth during a long prehistoric period. This result agrees with the conclusions already arrived at by the study of races and language.

Without attempting here to draw a picture of life as it may have been among men at their first appearance on the earth, it is important to go back as far as such evidence of the progress of civilization may fairly lead us. In judging how mankind may have once lived, it is also a great help to observe how they are actually found living. Human life may be roughly classed into three great stages, Savage, Barbaric, Civilized, which may be defined as follows. The lowest or *savage* state is that in which man subsists on wild plants and animals, neither tilling the soil nor domesticating creatures for his food. Savages may dwell in tropical forests where the abundant fruit and game may allow small clans to live in one spot and find a living all the year round, while in barer and colder regions they have to lead a wandering life in quest of the wild food which they soon exhaust in any place. In making their rude implements, the materials used by savages are what they find ready to hand, such as wood, stone, and bone, but they cannot extract metal from the ore, and therefore belong to the Stone Age. Men may be considered to have risen into the next or *barbaric* state when they take to agriculture. With the certain supply of food which can be stored till next harvest, settled village and town life is established, with immense results in the improvement of arts, knowledge, manners, and government. Pastoral tribes are to be reckoned in the barbaric stage, for though their life

of shifting camp from pasture to pasture may prevent settled habitation and agriculture, they have from their herds a constant supply of milk and meat. Some barbaric nations have not come beyond using stone implements, but most have risen into the Metal Age. Lastly, *civilized* life may be taken as beginning with the art of writing, which by recording history, law, knowledge, and religion for the service of ages to come, binds together the past and the future in an unbroken chain of intellectual and moral progress. This classification of three great stages of culture is practically convenient, and has the advantage of not describing imaginary states of society, but such as are actually known to exist. So far as the evidence goes, it seems that civilization has actually grown up in the world through these three stages, so that to look at a savage of the Brazilian forests, a barbarous New Zealander or Dahoman, and a civilized European, may be the student's best guide to understanding the progress of civilization, only he must be cautioned that the comparison is but a guide, not a full explanation.

In this way it is reasonably inferred that even in countries now civilized, savage and low barbaric tribes must have once lived. Fortunately it is not left altogether to the imagination to picture the lives of these rude and ancient men, for many relics of them are found which may be seen and handled in museums. It has now to be considered what sort of evidence of man's age is thus to be had from archæology and geology, and what it proves.

When an antiquary examines the objects dug up in any place, he can generally judge in what state of civilization its inhabitants have been. Thus if there are found weapons of bronze or iron, bits of fine pottery, bones of domestic cattle, charred corn, and scraps of cloth, this would be proof that people lived there in a civilized, or at least a high barbaric condition. If there are only rude implements of stone and bone, but no metal, no earthenware, no remains to show that the land was tilled or cattle kept, this would be evidence that the country had been inhabited by some savage tribe. One of the chief questions to be asked about the condition of any people is,

whether they have metal in use for their tools and weapons. If so, they may be said to be in the metal age. If they have no copper or iron, but make their hatchets, knives, spear-heads, and other cutting and piercing instruments of stone, they are said to be in the stone age. Wherever such stone implements are picked up, as they often are in our own ploughed fields, they prove that stone-age men have once dwelt in the land. It is an important fact that in every region of the inhabited world ancient stone implements are thus found in the ground, showing that at some time the inhabitants were in this respect like the modern savages. In countries where the people have long been metal-workers, they have often lost all memory of what these stone things are, and tell fanciful stories to account for their being met with in ploughing or digging. One favorite notion, in England and elsewhere, is that the stone hatchets are "thunderbolts" fallen from the sky with the lightning flash. It has been imagined that in the East, the seat of the most ancient civilizations, some district might be found without any traces of man having lived there in a state of early rudeness, so that in this part of the world he might have been civilized from the first. But it is not so. In Assyria, Palestine, Egypt, as in other lands, one may find sharp-chipped flints which show that here also tribes in the stone age once lived, before the use of metal brought in higher civilization.

Whether it may be considered or not that Europe was a quarter of the globe inhabited by the earliest tribes of men, it so happens that remains found in Europe furnish at present the best proofs of man's antiquity. To understand these, it must be explained that the stone age had an earlier and a later period, as may be plainly seen in looking at a good collection of stone implements. On the whole, these stone implements are much like those which the North American Indians have been using to our own day. The question is, how long ago tribes who made such stone implements were living in Europe. As to this, we may fairly judge from the position in which they are found in Denmark. The forests of that country are mainly of beeches, but in the peat-mosses lie innumera-

ble trunks of oaks, which show that at an earlier period oak forests prevailed, and deeper still there lie trunks of pine trees, which show that there were pine forests still older than the oak forests. Thus there have been three successive forest-periods, the beech, the oak, and the pine, and the depth of the peat-mosses, which in places is as much as thirty feet, shows that the period of the pine trees was thousands of years ago. While the forests have been changing, the condition of the people living among them has changed also. The modern woodman cuts down the beech trees with his iron axe, but among the oak trunks in the peat are found bronze swords and shield-bosses, which show that the inhabitants of the country were then in the bronze age, and lastly, a flint hatchet taken out from where it lay still lower in the peat beneath the pine trunks, proves that stone-age men in Denmark lived in the pine-forest period, which carries them back to high antiquity. In England, the tribes which have left such stone implements were in the land before the invasion of that Keltic race whom we call the ancient Britons, and who no doubt came armed with weapons of metal. The stone hatchet-blades and arrow-heads of the older population lie scattered over our country, hill and dale, moor and fen, near the surface of the ground, or deeper underground in peat-mosses, or beds of mud and silt. Such bogs or mud-flats began at a date which chronologists would call ancient. But they are what geologists, accustomed to vaster periods of time, consider modern. They belong to the newer alluvial deposits, that is, they were formed within the times when the lay of the land and the flow of the streams were much as they are now. To get an idea of this, one has only to look down from a hillside into a wide valley below, and notice how its flat flooring of mud and sand, stretching right across, must have been laid down by flood-waters following very much their present course along the main stream and down the side slopes. The people of the newer stone age lived within this historically ancient, but geologically modern period, and relics of them are found only in places where man or nature could then have placed them.

But there had been a still earlier period of the stone age, when yet ruder tribes of men lived in our parts of the world, when the climate and the face of the country were strangely different from the present state of things. On the slopes of river valleys such as that of the Ouse, in England, and the Somme, in France, 50 or 100 feet above the present river-banks, and thus altogether out of the reach of any flood now, there are beds of so-called drift-gravel. Out of these beds have been dug numerous rude implements of flint, chipped into shape by the hands of men who had gained no mean dexterity in the art, as any one will find who will try his hand at making one, with any tools he thinks fit. The most remarkable implements of this earlier stone age are the picks or hatchets. The coarseness of their finish, and the absence of any signs of grinding even at the edges of hacking or cutting instruments, show that the makers had not come nearly to the skill of the later stone age. It is usual to distinguish the two kinds of implements, and the periods they belong to, by the terms introduced by Sir J. Lubbock, *palæolithic* and *neolithic*, that is "old-stone" and "new-stone."

Looking at the high gravel-beds in which *palæolithic* implements such as these occur, it is evident from their position that they had nothing to do with the water-action which is now laying down and shifting sand-banks and mud-flats at the bottom of the valleys, nor with the present rain-wash which scours the surface of the hillsides. They must have been deposited in a former period when the condition of land and water was different from what it is now. How far this state of things was due to the valleys not being yet cut out to near their present depth, to the whole country lying lower above the sea-level, or to the rivers being vastly larger than at present from the heavier rainfall of a pluvial period, it would be raising too intricate geological questions to discuss here. Geology shows the old drift-gravels to belong to times when the glacial or icy period with its arctic climate was passing, or had passed away, in Europe. From the bones and teeth found with the flint implements in the gravel-

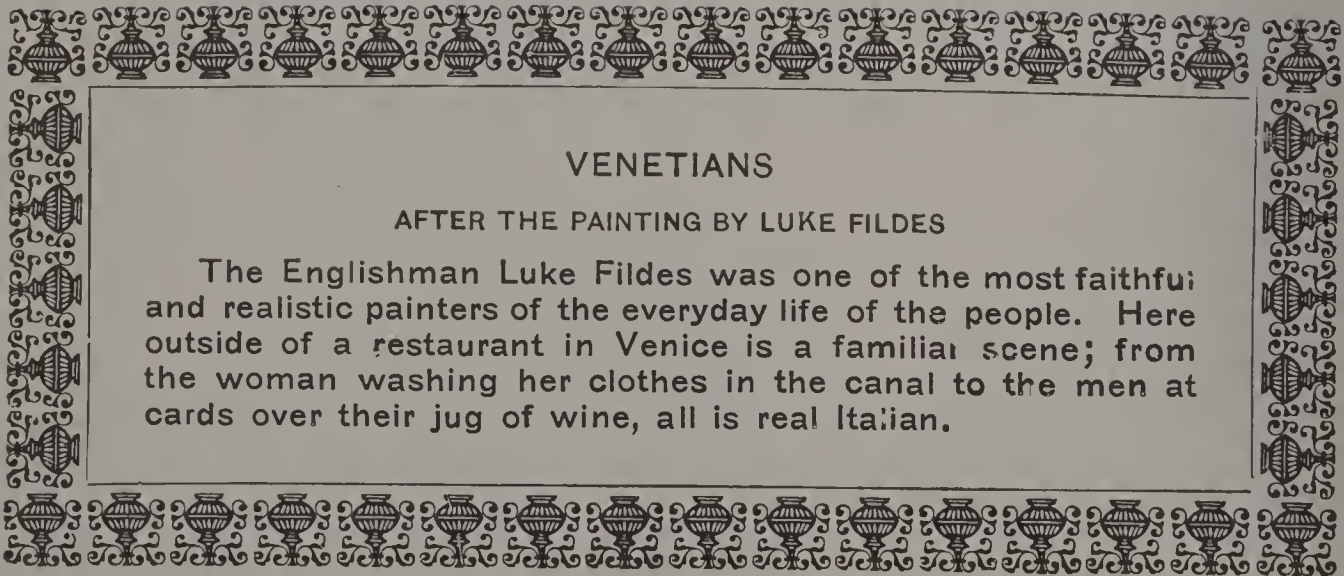
beds, it is known what animals inhabited the land at the same time with the men of the old stone age. The mammoth, or huge woolly elephant, and several kinds of rhinoceros, also extinct, browsed on the branches of the forest trees, and a species of hippopotamus much like that at present living frequented the rivers. The musk-ox and the grizzly bear, which England harbored in this remote period, may still be hunted in the Rocky Mountains, but the ancient cave-bear, which was one of the dangerous wild beasts of our land, is no longer on the face of the earth. The British lion was of a larger breed than those now in Asia and Africa, and perhaps than those which Herodotus mentions as prowling in Macedonia in the fifth century B.C., and falling on the camels of Xerxes' army. To judge by such signs as the presence of the reindeer, and the mammoth with its hairy coat, the climate of Europe was severer than now, perhaps like that of Siberia. How long man had been in the land there is no clear evidence. For all we know, he may have lasted on from an earlier and more genial period, or he may have only lately migrated into Europe from some warmer region. Implements like his are not unknown in Asia, as where in Southern India, above Madras, there lies at the foot of the Eastern Gháts a terrace of iron clay or laterite, containing stone implements of very similar make to those of the drift-men in Europe.

These European savages of the mammoth-period resorted much to shelter at the foot of overhanging cliffs, and to caverns such as Kent's Hole near Torquay, where the implements of the men and the bones of the beasts are found together in abundance. In Central France especially, the examination of such bone-caves has brought to light evidence of the whole way of life of a group of ancient tribes. The reindeer which have now retreated to high northern latitudes were then plentiful in France, as appears from their bones and antlers imbedded with remains of the mammoth under the stalagmite floors of the caves of Perigord. With them are found rude stone hatchets and scrapers, pounding-stones, bone spear-heads, awls, arrow-straighteners, and other objects be-

longing to a life like that of the modern Esquimaux who hunt the reindeer on the coasts of Hudson's Bay. Like the Esquimaux also, these early French and Swiss savages spent their leisure time in carving figures of animals. Among many such figures found in the French caves is a mammoth, scratched on a piece of its own ivory, so as to touch off neatly the shaggy hair and huge curved tusks which distinguished the mammoth from other species of elephant. There has been also found a rude representation of a man, grouped with two horses' heads and a snake or eel; this is interesting as being the most ancient human portrait known.

Thus it appears that man of the older stone age was already living when the floods went as high above our present valley-flats as the tops of the high trees growing there now reach, and when the climate was of that Lapland kind suited to the woolly mammoth and the reindeer, and the rest of the un-English-looking group of animals now perished out of this region, or extinct altogether. From all that is known of the slowness with which such alterations take place anywhere in the lie of the land, the climate, and the wild animals, we cannot suppose changes so vast to have happened without a long lapse of time before the newer stone age came in, when the streams had settled down to near their present levels, and the climate and the wild creatures had become much as they were within the historical period. It is also plain from the actual remains found, that these most ancient known tribes were wild hunters and fishers, such as we should now class as savages. It is best, however, not to apply to them the term primitive men, as this might be understood to mean that they were the first men who appeared on earth, or at least like them. The life the men of the mammoth-period must have led at Abbeville or Torquay, shows on the face of it reasons against its being man's primitive life. These old stone-age men are more likely to have been tribes whose ancestors while living under a milder climate gained some rude skill in the arts of procuring food and defending themselves, so that afterwards they were able by a hard struggle to hold their own





VENETIANS

AFTER THE PAINTING BY LUKE FILDES

The Englishman Luke Fildes was one of the most faithful and realistic painters of the everyday life of the people. Here outside of a restaurant in Venice is a familiar scene; from the woman washing her clothes in the canal to the men at cards over their jug of wine, all is real Italian.

against the harsh weather and fierce beasts of the time.

How long ago this period was, no certain knowledge is yet to be had. Some geologists have suggested twenty thousand years, while others say a hundred thousand or more, but these are guesses made where there is no scale to reckon time by. It is safest to be content at present to regard it as a geological period lying back out of the range of chronology. It is thought by several eminent geologists that stones shaped by man, and therefore proving his presence, occur in England and France in beds deposited before the last glacial period, when much of the continent lay submerged under an icy sea, where drifting icebergs dropped on what is now dry land their huge boulders of rock transported from distant mountains. This cannot be taken as proved, but if true it would immensely increase our estimate of man's age. At any rate the conclusive proofs of man's existence during the quaternary or mammoth period do not even bring us into view of the remoter time when human life first began on earth. Thus geology establishes a principle which lies at the very foundation of the science of anthropology. Until of late, while it used to be reckoned by chronologists that the earth and man were less than 6,000 years old, the science of geology could hardly exist, there being no room for its long processes of building up the strata containing the remains of its vast successions of plants and animals. These are now accounted for on the theory that geological time extends over millions of years. It is true that man reaches back comparatively a little way into this immense lapse of time. Yet his first appearance on earth goes back to an age compared with which the ancients, as we call them, are but moderns. The few thousand years of recorded history only take us back to a prehistoric period of untold length, during which took place the primary distribution of mankind over the earth and the development of the great races, the formation of speech and the settlement of the great families of language, and the growth of culture up to the levels of the old world nations of the East, the forerunners and founders of modern civilized life.

SOME FACTS ABOUT OUR WONDERFUL WORLD AND THE RACES OF MANKIND.

According to Clark, the equatorial semi-diameter is 20,926,202 feet=3963.296 miles, and the polar semi-diameter is 20,854,895 feet=3950.738 miles. One degree of latitude at the pole=69.407 miles. One degree of latitude at the equator=68.704 miles.

POPULATION OF THE EARTH BY CONTINENTS.

(The figures of the Royal Geographical Society, previous to 1915, revised by the National Geographical Society, Washington, represent the "best available data," but as given for 1919 they must not be understood as representing final estimates of the effect of the World War on population. The reduction of the total of 1,732,000,000 inhabitants for the entire earth in 1914 to 1,692,000,000 in 1919 is chiefly due to a reduced estimate of the population of Asia and Africa.)

Continental Divisions	Area in Square Miles	Inhabitants		Continental Divisions	Area in Square Miles	Inhabitants	
		Number	Per Sq. Mile			Number	Per Sq. Mile
Africa.....	11,622,619	142,751,000	12.3	Australasia.	3,312,613	16,228,591	4.9
America, N.	8,589,257	140,084,000	16.3	Europe.....	3,872,561	464,681,000	121
America, S.	7,570,015	56,337,775	7.4	Polar Reg..	5,081,935		
Asia.....	17,206,000	872,522,000	50.7	Total....	57,255,000	1,692,604,366	29.6

*² Ravenstein's estimate of the earth's fertile region, in square miles, is 28,269,200; steppe, 13,901,000; desert, 4,180,000; polar regions, 4,888,800.

The population of the earth at the death of the Emperor Augustus, estimated by Bodio, was 54,000,000. The population of Europe hardly exceeded 50,000,000 before the fifteenth century.—*Mulhall*.

The area and cubic contents of the earth, according to the data of Clark, given above, are: Surface, 196,971,984 square miles; cubic contents, 259,944,035,515 cubic miles.

Murray (Challenger expedition) states the greatest depth of the Atlantic Ocean at 27,366 feet; Pacific Ocean, 30,000 feet; Indian Ocean, 18,582 feet; Southern Ocean, 25,200 feet; Arctic Ocean, 9,000 feet. The Atlantic Ocean has an area in square miles of 24,536,000; Pacific Ocean, 50,309,000; Indian Ocean, 17,084,000; Arctic Ocean, 4,781,000; Southern Ocean, 30,592,000. The highest mountain is believed to be Deodhunga or Everest, one of the Himalayas, 29,002 feet.

POPULATION OF THE EARTH ACCORDING TO RACE.

Race	Location	Number	Race	Location	Number
Indo - Germanic or Aryan (white).....	Europe, Persia, etc.....	796,000,000	Malay and Polynesian (brown).....	Australasia & Polynesia...	35,000,000
Mongolian or Turanian (yellow and brown)	Greater part of Asia	630,000,000	American Indian (red and mixed) ..	North and So. America....	27,000,000
Semitic or Hamitic (white)	North Africa, Arabia	70,000,000	Total		1,692,000,000
Negro and Bantu (black)	Central Africa	184,000,000			

The human family is subject to more than sixty governments, including those formed after the World War. They include republics, constitutional monarchies, absolute monarchies and empires, which may be constitutional in one part of their territories, while holding other parts under military control. The smallest independent country of the world in 1920 was Monaco with only eight square miles. The greatest empire in territorial extent was the British.

Adapted from "The World Almanac," by permission.

EUROPEAN LANGUAGES SPOKEN.

Lan- guages	Number of Persons Spoken by		Proportion of the Whole		Lan- guages	Number of Persons Spoken by		Proportion of the Whole	
	1801	1916	1801	1916		1801	1916	1801	1916
English...	20,520,000	160,000,000	12.7	27.3	Portuguese	7,480,000	25,000,000	4.7	4.3
French...	31,450,000	70,000,000	19.4	11.9	Russian...	30,770,000	100,000,000	19.0	17.1
German..	30,320,000	130,000,000	18.7	22.2	Total....	161,800,000	585,000,000	100.0	100.0
Italian...	15,070,000	50,000,000	9.3	8.6					
Spanish..	26,190,000	50,000,000	16.2	8.6					

These estimates (that for 1801 being by Mulhall) exhibit the superior growth of the English language.

The average duration of human life is about 33 years. One-quarter of the people on earth die under 6 years old, one-half before 16, and only about one persons in each 100 born, live to 65.

RACES OF MANKIND.

The following is compiled from the arrangement by the Ethnologist Figuier and others:

WHITE RACE.

European Branch	Teutonic Family...	Scandinavians, Germans, English.
	Latin Family	French, Spaniards, Italians, Moldo-Wallachians.
	Slavonian Family..	Russians, Finns, Bulgarians, Servians, Magyars, Croats, Tchecks, Poles, Lithuanians.
	Greek Family.....	Greeks, Albanians.
Aramean Branch	Libyan Family.....	Egyptians, Berbers.
	Semitic Family....	Arabs, Jews, Syrians.
	Persian Family....	Persians, Afghans, Kurds, Armenians, Ossetines.
	Georgian Family...	Georgians.
	Circassian Family..	Circassians, Mingrelians.

YELLOW RACE.

Hyperborean Branch	Lapp Family.....	Samolede, Kamtsehadale, Esquimau, Tenisian, Jukaghirite, and Koriak Families.
Mongolian Branch	Mongol Family....	Mongols, Kalmucks, Buriats.
	Tunguse Family...	Tunguses, Manchus.
	Turk Family.....	Turcomans, Kirghis, Nogays, Osmanlis.
Sinaic Branch	Yakut Family.....	Yakuts.
	Chinese Family...	Chinese.
	Japanese Family...	Japanese.
	Indo-Chinese Family	Burmese, Siamese.

BROWN RACE.

Hindoo Branch	Hindoo Family.....	Sikhs, Jats, Rajpoots, Mahrattas, Bengalese, Cingalese.
Ethiopian Branch	Malabar Family....	Malabars, Tamals, Telingas.
	Abyssinian Family.	Abyssinians, Berabras, Gallas.
	Fellah Family.....	Fellahs.
Malay Branch	Malay Family.....	Malays, Javanese, Battas, Bougis, Maccassars, Dyaks, Togals.
	Polynesian Family.	Maoris, Tongas, Tahitians, Pomotouans, Marquesans, Sandwichians.
	Micronesian Family	Ladrone, Caroline, and Mulgrave Islanders.

RED RACE.

Southern Branch	Andian Family.....	Quichuas (or Incas), Antis, Andians, Araucanians.
	Pampean Family...	Patagonians, Puelches, Charruas, Tobas, Moxas, Abipous, etc.
	Guarani Family....	Guaranis, Bocotudos.
Northern Branch	Southern Family...	Aztecs, Mayas, Lencas, Othomis, Tarascas, etc.
	Northeastern Family	Cherokees, Hurons, Iroquis, Sioux, Apaches, Comanches, Creeks, etc.
	Northwestern Family	Chinooks, Digger Indians, Nootkans, etc.

BLACK RACE.

Western Branch	Kaffir Family.....	
	Hottentot Family..	
	Negro Family.....	
Eastern Branch	Papuan Family....	Fijians, New Caledonians, etc.
	Andaman Family...	Andamans, Australians.

STRANGE PEOPLES.

BY

FREDERICK STARR.

PROFESSOR OF ANTHROPOLOGY, UNIVERSITY OF CHICAGO

THERE is an old saying,—

“Many men of many minds;
Many birds of many kinds;
Many fishes in the sea;
Many men who don’t agree.”

Peoples differ in so many ways. There are tall Patagonians and short Bushmen. There are white peoples, and black, yellow, and brown peoples. There are peoples whose bodies are so covered with hair as almost to be called furry, and there are peoples whose faces even are hairless except for eyebrows and eyelashes. There are lively peoples and there are sluggish peoples; gay peoples and sad ones. Negroes do not think and feel like white men, and the Chinaman thinks and feels differently from either. All peoples have their own customs. When we speak of other peoples as *Strange Peoples*, we must never forget that we are as *strange* to them as they are to us. We think it curious that the Chinese dwarf, by bandaging, the feet of their women; they think it strange that we do *not*. To us the Chinese face seems much too flat; the Chinese think ours are like the face of an eagle and that they are harsh and cruel. We think the flat, wide nose of the negro is ugly; negroes think it far handsomer than ours. So we will remember that all these peoples are “strange” only because they are *unlike* us: that we ourselves are just as strange as they are. They have as much right to their ideas and customs as we have to ours: often indeed we might find theirs better than our own.

We begin with North America. We then pass to South

From “Strange Peoples.” Boston. Copyright by D. C. Heath & Co. By permission.

America; then to Europe, Asia, Africa, and the Pacific Islands in order. We shall find that the different peoples of the world are not scattered haphazard; on the contrary, they are quite regularly distributed by types. Thus until lately the peoples living in America were all Indians, with red-brown skin, straight and coarse black hair, and high and wide cheek bones. Europe and Northern Africa (which really belongs rather to Europe than Africa) form the land of the white peoples. South Africa—Africa proper—is the home of negroes and negroids, with dark brown, almost black, skin, narrow heads and faces, and woolly hair. The proper population of Asia is yellow peoples, with round heads, slant eyes, and straight, long, black hair. In Australia are brown peoples with curly or bushy hair. In Oceanica are several well-marked types—the little brown Malays, the dark, almost black, Melanesians with crinkly hair, and the tall, well-built, fine-featured, light Polynesians. This is, in general, the distribution of the human races. But there has been much movement. There are now both whites and blacks in America; the English whites have crowded in upon the natives of Australia; in Asia there are white peoples, like the Ainu and Todas, who have certainly lived there a long time.

The different peoples are unlike in their culture. Some peoples live on wild food, having no cultivated plants or domestic animals. They hunt animals and catch fish; they search for birds' eggs and honey; they grub up roots and gather barks, leaves, fruits, seeds, and nuts for food. To such tribes, who usually wander in little bands from place to place, the name savage is given. The word does not mean that they are fierce and cruel in disposition; most savage tribes, to-day living, are neither. The Eskimo and Mincopies are savages, but they are quite kind and gentle. When peoples settle down to cultivate the soil and build homes, or when they raise herds of animals with which they move from time to time for new pastures, their life is easier. To such peoples—so long as they do *not* know how to work iron by smelting, to write by means of characters that represent sounds, and

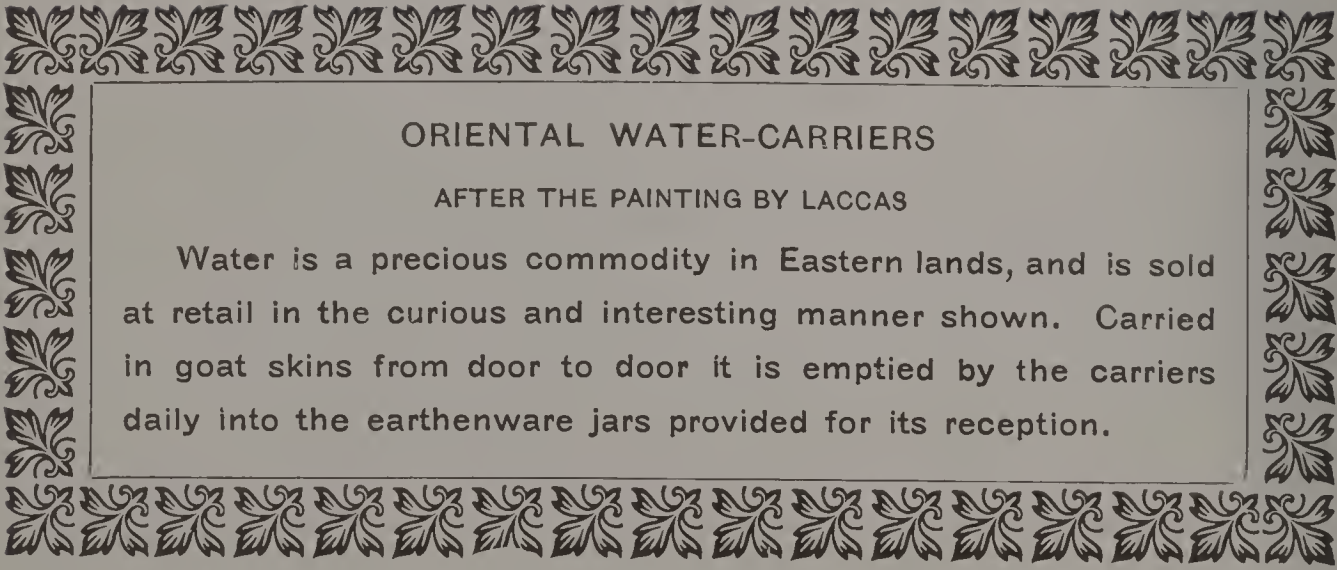
to make animals assist them in tilling the ground—the name barbarian is applied. When any peoples have learned these three great helps, they are called civilized. There are then three great stages of culture—savagery, barbarism, and civilization. The Eskimo is in savagery; the American Indians are mostly in barbarism; the Chinese are in civilization.

The way in which the life of peoples is affected by the lands in which they live is most interesting. The Eskimo lives in the cold north; there is little wood there for construction; fuels such as are used elsewhere are rare; no fibre-yielding plants grow there. Yet the Eskimo has made full use of what nature gives him. He builds his house, when necessary, of the snow itself, heats it with animal fats and oils, clothes himself in excellent garments of skins, knows the ways of all the animals and birds around him for their destruction, and has invented an ideal hunter's boat and devised a beautiful series of weapons and tools. The way in which he has fitted himself to the place in which he lives is wonderful. The world over we notice the same thing: man everywhere ransacks his home-land to find out what is useful and turns it to his needs.

Often where two different peoples live in the same district marriage takes place between them, and mixed types arise. Where one people has long occupied a country alone the type is very well-marked, and all look alike. Thus in the Andaman Islands, the little Mincopies look so much alike that a person needs to know them well to tell them apart. We, ourselves, are a great mixture. Even in one family there may be tall and short, light and dark, blue-eyed or brown-eyed persons. Such differences are only found where there has been much mixing between different peoples. In Mexico, once purely Indian, there has been since the coming of the Spaniards much mixture, and to-day a large part of the population is of a new type—part Indian, part Spanish. The people range in color from almost white to dark brown according to the amount of Spanish or Indian blood each has. . . .

There are few unknown peoples left. Travellers have



A decorative border consisting of a repeating pattern of stylized floral or leaf motifs, arranged in a rectangular frame around the text.

ORIENTAL WATER-CARRIERS

AFTER THE PAINTING BY LACCAS

Water is a precious commodity in Eastern lands, and is sold at retail in the curious and interesting manner shown. Carried in goat skins from door to door it is emptied by the carriers daily into the earthenware jars provided for its reception.

gone to almost all parts of the world. The spots which represent absolutely unexplored regions on our maps are now neither large nor numerous. There are many peoples about whom we know little, but there are not many who are actually unknown. Those that may be discovered hereafter will be interesting, but they are not likely to be very different from those now known.

Many of the Strange Peoples are becoming less "strange" every year. Old customs and peculiar practices are dying out in every part of the world. Travelers, missionaries, and merchants from white men's lands are taking our ideas, our tools, our weapons, our dress, our learning, our religion, and our vices to the remotest parts of the world. Some of the Strange Peoples here described have already lost most of their old customs. The Polynesians and Fijians have little of the old life (left). . . . Many American Indian tribes have changed less. Some populations have still changed little. But a tribe must indeed be remote and difficult of access to actually escape our touch absolutely. Usually the change is *not* improvement. Other peoples more quickly adopt our vices than our virtues. Many tribes have become drunken, diseased, and depraved through the white man's influence. It is rare, indeed, that a lower people gains in happiness or virtue by contact with "higher civilization."

Many of the Strange Peoples will disappear. The Tasmanians were killed off almost like so many animals by the English. American Indian tribes have suffered almost as badly at our hands. Many tribes have gone; others are going. The Lipans were once a fairly numerous tribe. In 1892 I saw all who were left in the United States—four women and one man; six months later I saw them again—the man was dead and only four women remained. The Tonkaways are dying out at the rate of one-third each eight years. The Polynesians, strong, handsome, active, and happy as they were when James Cook visited their islands little more than one hundred years ago, have dwindled, and fifty years more may blot them from the earth. Not all American Indian tribes

are dying out; it is possible too that Polynesian decline began before Cook's travels. But it is certain that on the whole the changes brought by the newcomers sealed the doom of the Indian and Polynesian.

There have always been movements of peoples from place to place. We have seen the Malays pouring their great masses of immigrants into the Philippines. There are white peoples in Asia; there are yellow peoples in Europe. Recently plenty of whites and of blacks have poured into America. Such movements contain some danger. The fair whites will probably never be able to live in the tropical lands. A certain sort of skin, hair, nose, breathing apparatus, is necessary for men who are to live and prosper in low, hot, marshy parts of Africa. For Germans to try to *colonize* equatorial Africa was probably a fatal blunder. So far as we know the dark whites—Spaniards, Italians, south Frenchmen—make better tropical colonizers than we do; but even they are not successful. The negro is a bad colonizer, he hardly holds his own even in our Southern states. Of all the peoples of the globe the Chinese seem to be the best able to colonize differing countries. He seems to go to hot lands and cold lands, to small islands and to great continents, but flourishes everywhere. So true is this that some writers have urged that Africa be opened up for settlement to the crowded millions of the old empire. For most peoples, however, migration, if they *must* migrate, is best along the lines of latitude into lands as much like the old home as possible. Many Scandinavians live to-day happily where Wisconsin, Iowa, and Michigan join; and they may be expected to prosper there, for land and water, soil and products, scenery and climate, are there much what they were in the fatherland.

THE BOOMERANG.

THE people of Africa and Oceanica still use the javelin as well as the bow; but of all the projectiles employed by savages the most curious is the boomerang, a sort of club bent at almost a right angle, smooth on one side, slightly hollowed on the other. It is necessary that it should be made of a single piece of wood, in order not to get out of the form upon which its wonderful properties depend. At first sight, and without examining it closely, one would say it was a sword of wood rudely and unskilfully shaped. The first Australian explorers were deceived, but their error was pardonable, for the boomerang, though a weapon of war, is also equally used in hunting.

The specially interesting and original feature of the boomerang is that when thrown by the natives it describes the most extraordinary curves, and performs the most unaccountable evolutions. "When thrown by the natives," we say, for, whether from ignorance of the principle of the boomerang, or from want of skill, Europeans have never been able to use it. Thrown by strangers it flies and falls like any ordinary piece of wood.

In hurling this curious weapon the native takes it in the right hand by a species of handle into which one of the two branches is fashioned, and throws it either into the air at some distance above the ground, as one might throw, for example, a reaping-hook, or upon the ground, like a pair of compasses with the legs extended, which a schoolboy might throw to the distance of some paces from him out of spite. In the latter case the projectile strikes the ground at a little distance from where the thrower stands, but, owing to its bent form, and the elasticity which it gives, it rebounds immediately, and continues to rebound in successive ricochets, with a force which is most destructive to any body, organic or inorganic, that happens to lie in its course. Thrown thus

From "Wonders of Bodily Strength and Skill." From the French of Guillaume Depping.

among a flock of wild ducks, the boomerang commits the greatest havoc, striking many of the fowls, and killing wherever it strikes. The other mode of using the boomerang, much more curious, but at the same time more practicable than that described, consists in hurling the weapon at an object standing sometimes at a great distance. The thrower waits calmly till the boomerang, having accomplished its work of destruction, returns, describing an ellipse, and falls at the spot (or at the most a few paces from it) from which it was discharged.

Very few boomerangs have been brought to Europe, and, indeed, very many people are in ignorance of the existence of the weapon. When it becomes better known, when men of science shall have examined it with intelligent care, perhaps some means of applying it usefully will be found. The case of the boomerang proves clearly that the most simple laws of nature have not, even among civilized nations, been sufficiently utilized. And it is not flattering to our *amour-propre* that this lesson in mechanics comes to us from Australia, from a country the inhabitants of which are among the least civilized and the least capable of civilization. One is perfectly nonplussed in attempting to explain how savage tribes, utterly ignorant of physics and the laws of dynamics, could have conceived the idea of an instrument at once so ingenious and so simple. It was no doubt chance that first made them acquainted with the properties of a piece of wood thus shaped; and one can imagine how, in the chase, an Australian, having in his hand a curved stick, and throwing it at the wild fowl, was astonished to see it come back to his side; how, being a keen observer, the strange fact made a deep impression upon him; and how, after endless trials, he arrived at a satisfactory result, and fashioned another instrument like the one chance had put into his hands.

However this may be, the natives use this instrument with extraordinary skill, and travellers recount incredible feats performed by them. Thus, a native throws his boomerang with his right hand, and catches it again with his left, and *vice versâ*. They hit unerringly objects con-

cealed by other bodies—strike down, for example, birds or other small animals hidden behind trees or houses. Nearer objects they also hit by a back-stroke. The perfection of skill is to strike the enemy with a double boomerang—that is, with one discharged with the right and another sent by the left hand. The unhappy man who serves as target thus finds himself between two fires, or rather between two clubs, which, after describing eccentric courses, both infallibly strike him, unless he is sufficiently skilful to escape by a *ruse*, or is possessed of a shield of a particular shape, behind which he may shelter himself.

It is possible to calculate mathematically the curve which the boomerang describes. Commodore Wilkes, who commanded the celebrated scientific expedition of the United States round the World, made experiments with this instrument, and has traced the curves described by it when discharged at the angles of 22° , 45° , and 65° . The most singular movement is that which is performed when the weapon is thrown at the angle of 45° . Its flight is then effected from behind—the thrower turning his back to the object which he wishes to strike.

But by virtue of what principle is the phenomenon accomplished? Travellers who have visited Australia, either do not try to investigate the cause, or give an insufficient explanation, or plainly say that the thing is incomprehensible. Willingly would they leave it alone as a prodigy; but in these scientific days prodigies are no longer the fashion. In the first place, how comes it that the boomerang does not follow the straight line like other bodies thrown in the same manner? Its particular form is the cause, and as the straight line in which the force of projection tends to drive it does not pass through the centre of gravity—which lies outside the mass, a little nearer the longer than the shorter leg of this unequal pair of compasses—the instrument rotates continuously around the centre of gravity. The force of this movement is so great that it diminishes but little before the weapon falls. The boomerang, by means of its level surface, easily cuts the air which sustains it, and, so to

speak, carries it. For example, if the weapon is thrown with a slightly upward tendency, it mounts considerably upwards, a phenomenon which, perhaps, has led to several travellers believing that the natives always throw it higher, whereas they project it only a slight distance above, and indeed sometimes close to the earth. In any case, it is by the influence of the air that the upward movement is caused; but, on the other hand, centrifugal force exercises its influence, and tends to sweep the mass round in an orbit. This makes the boomerang describe an ellipse, which attains its maximum of curve when the movement is arrested by the resistance of the air.

THE BURMAN.

BY

R. TALBOT KELLY.

LIVING amidst such environment and enjoying a climate which, to say the least, does not predispose to exertion, one need hardly expect to find a great deal of backbone or moral fibre among the people. Provided by nature with most of their requirements, or at least with the minimum of exertion on their part, the spur of necessity is absent and good-natured self-content results.

Naturally perhaps their thoughts are directed largely to amusement and personal adornment, and one is forced to the conclusion that there is something peculiarly fitting in the adoption of the peacock as their national emblem by a people who modestly entitle the king's throne at Mandalay "the centre of the universe." Conceit and good-nature are perhaps their two most striking characteristics. Even to-day, nearly twenty years after the deposition of Thebaw, it is difficult to persuade the most intelligent Burman that any power has been able to overcome the prowess of his country and remove the king from his high position. The majority seem to believe

From "Burma Painted and Described." By R. Talbot Kelly.

that Thebaw will reappear one day to resume control of affairs now temporarily administered by white "thakins."

One cannot but regret the introduction of our strenuous Western life into this Arcadia, and, as a matter of fact, our occupation of Burma has practically destroyed a nation. Even after Thebaw's deposition the Burmese fought long and ably, but with the final subjugation of Upper Burma the native went to the wall. Placidly accepting the position, he appears to be quite content that we should administer the country so long as he is left in full enjoyment of his gay clothing and sporting events. Meanwhile other races, notably Chinese, Japanese, and Indian merchants, have not been slow to take advantage of the new order of things and profit by the increased trade consequent upon a more stable government. The result has been the gradual ousting of the male Burman from all employment, while his own easy-going nature limits enterprise on his own part.

The women, on the other hand, have great business capabilities, and conduct most of the internal trade of the country. Despising the indolence of the men, it has become an ever-increasing habit with them to mate with the more energetic males of other countries, and there is springing up a new race in which Burmese characteristics are fast disappearing. An example of the independent position occupied by women in Burma was afforded during a trial in the High Court of Rangoon. A woman who was giving evidence was asked by the judge what she did. "Me keep stall in bazaar." "But where is your husband?" "He stayed t'ome and minded the children."

Personal adornment, though a weakness, is happy in its results, for the Burmese crowd is perhaps the gayest in the world; and it is worth notice that the fabrics they wear are good, and, though the women are often overbedecked with jewelry, they never wear any but good stones, paste and imitations being unknown among them.

Like their clothing, many idioms of the language are extremely poetic. Take, for example, the Burmese ideas of time: The times of day are thus described: "One crow

of cock," "Two crows of cock," "Three crows of cock," "Dawn great force," "When the sun is one palm-tree high," "The hour when the hpungyis beg" (9 A.M.), etc. The evening hours are no less picturesque, as for instance, "The time when children lay down their heads," "The time when old men lay down their heads," "The time when feet become silent," "The time when young men go courting" (8 to 9 P.M.), "The return of the young lads" (10 P.M.), when, I am told, begins the courting proper!

Similarly, the names they give their daughters are generally pretty. For instance: Ma Sein (Miss Diamond), Ma San-hla (Miss Pretty Hair), Ma Pan-byu (Miss White Flower), Ma Ma-gale (Miss Little Mother), etc., etc.; while periods of time are denoted by such terms as "A betel chew," "A pot boil," or "The passing of a train."

Though not essentially a brave race, the Burman has plenty of moral courage of a sort, and apparently an indifference to pain, whether in himself or others. This story will illustrate this attitude. Two Burmans attending a pwe, instead of confining themselves to their native "toddy," procured a bottle of gin and became very drunk. With the valor of liquor upon them, they vowed to "go for" the first thing they met on the road. This happened to be a pi dog, which eluded them in the dark. "Never mind," they said, "we will take the next." The next happened to be an old woman, whom they promptly cut to bits with their dahs. On being accused they replied, "Oh yes, we did it, we said we would, so we had to," and with the most complete unconcern they submitted to the beheading which followed. A Burman will go to execution without flinching, but will often run away and leave his wife and children unprotected if attacked. Dacoits also, though occasionally showing extreme bravery, are much the same, and it is usually a question of which will run first should serious resistance be offered.

Thanks to a very complete and vigilant police system, dacoity seems to be on the wane in Burma, though naturally isolated cases of robbery and violence occur here as in other countries. Considerable ingenuity is often ap-

plied to the conduct of a theft, an amusing instance of which came under my notice at Pyinmana. Several men armed with long poles, at the ends of which were tied the prickly leaves of the cactus, lined up alongside the railway and awaited the arrival of the train from Mandalay. As the train passed all shouted, the consequence being that every one in the train put out his head to see what was the matter, whereupon the thieves quickly hooked off all the silk turbans with their "fishing rods"! Shrieks of laughter from the thieves greeted the speechless indignation of the sufferers, who, with many a scratched face, were carried helplessly away in the disappearing train. Bribery also is not unknown in Burma, and I was rather tickled on one occasion in the forest when, replying to a facetious remark on my part, a native looked up and said, "If master will take I will offer."

The Burmans are fond of sport in all its branches, no business being of sufficient importance to interfere with a cock fight or a pony race, and relatively large sums are wagered on these events. So keen are they that in their bullock-gharry races partisans will mow down the grass and remove stones and other obstructions which may possibly come in the way of the wheels of the gharry they are supporting, and from infants to old men all display the wildest excitement during the progress of such events.

This predilection for sport was rather well exemplified a short time ago at Pegu. The bund broke, letting in the river which inundated the whole surrounding district, only the roofs of the houses appearing above water. Cattle were swimming about and finding refuge on any eminence available, poultry and other farm stock scrambling up the roofs or drowning in the stream. One Burman, whose house was flooded and his wife, dry but disconsolate, seated on the roof, concerned himself little about wife or struggling live stock, but considering this a heaven-sent opportunity, was seen vigorously paddling about in a canoe, training for a coming race!

Cleanly and simple in their habits, the Burmans live almost entirely upon rice, drinking little else but water,

though they chew an enormous quantity of betel nut, which is a good stomachic, but has the effect of blackening the teeth and imparting a curious vermilion tint to lips and tongue. From one day old infants are fed on rice, a small bowl of this and another of water being measured out for them at meals, the amount of each increasing as the child grows. The rice, however, is not cooked dry as in India, but the water being left with it, it is soft and glutinous, and is first chewed up by the women before being given to the infant, together with a few drops of water with which to wash it down.

Forbidden by their religion to take life, meat seldom forms part of their diet, and to such an extreme is this principle carried that they sometimes even decline to milk their cows, who become dry in consequence. Fish, however, is constantly used, and in the bazaars, where meat is offered for sale by Indians and people of other religions, the Burmans do not scruple to buy and consume it.

There is no division of class in Burma. In the king's time any one might become a prince, and the office of prime minister or any other high position be attained by people of the lowest rank.

Theoretically all are equal, the holding of office alone marking a social grade. A good instance of this was given me by the captain of one of my steamers, who on one occasion, long ago, had been invited by the Lord High Admiral of the Burmese fleet to attend the ceremony of his daughter's "ear-boring," when a large company had assembled to drink warm lemonade and smoke Burmese cheroots as from the Admiral's box they witnessed the pwe which followed. It was altogether a great festival, and attended by all the ceremony and pomp due to the position of his host, who at that time had power of life or death over every man in the navy. Some weeks later he again saw him, but in the interim he had been degraded, and was now paddling about in a dug-out canoe, cutting and selling kaing grass to the king's elephant-keepers! It was a descent from the palace to the hut, from robes of office to the simple loin-cloth, yet he was the same dignified gentleman he had been before, and

though perhaps not so corpulent as of yore, was still smiling and apparently contented with his lot.

The Burmans have few modes of expression in Art. I am not aware of any great literary work having been produced by them, and their music is primitive if pleasing, while—owing, no doubt, to the temporary nature of their homes, due to constantly changing sites—pictorial art is practically non-existent. Such pictures as I have seen are the archaic frescoes on temple walls and vaults, and the distemper paintings used in the embellishment of “tan-yin” or kyaungs.

On the other hand, their silk fabrics are very beautiful, and their silver-work quite the finest in the world.* This art, however, is only practised in a few centres, such as Rangoon, Mandalay, and Thayetmyo, and is characterized by the exquisite modelling and extraordinarily high relief of the figures or foliage with which they embellish bowls and vases in themselves beautiful in form.

It is in their religious buildings, however, that we recognize the chief expression of their art sense, where, influenced by their environment and imitating the exuberance of nature, they are elaborate in design and lavish in their decoration. Their plaster-work is excellent, and teak carving almost unique. They are fond of introducing human and animal forms into their carvings, from life-sized figures of dancing men and women to the innumerable little effigies of beloos, nats, and other supernatural forms which decorate the eaves and cornices of the kyaungs. In the pagodas, guarded by griffins which have always a highly decorative feeling, a common form I noticed was that of the peacock perched upon a crocodile, no doubt emblematical of the triumph of beauty over what is vile, in which perhaps is also implied a religious parallel.

I remember that on landing at Rangoon a friend remarked to me that I would soon “become sick of pagodas,” and certainly the great number one sees on the Irrawaddy and throughout the country generally almost

*An authoritative monograph upon this subject has been published by Mr. H. L. Tilly, Collector of Customs, Rangoon.

justifies such a remark, every point of vantage apparently being utilized by the Burman upon which to build his temple. It must be acknowledged that they add considerably to the beauty of the landscape, but apart from any pictorial value they may possess, I must say that, far from becoming tired of this continuous succession of temples, I found my interest grow rather than diminish upon fuller acquaintance.

At first sight one temple or pagoda is much like another, and it is a graceful object at that, but on comparing the various periods and styles, what a difference is noticeable! All more or less conform to the graceful zedi form of design, yet no two are alike. The plinths are sometimes square, again octagonal or polygonal, receding in successive stages—each differently ornamented—to the base of the dome. This again is built in stages, each representing in conventional form some familiar object, such as the rice bowl, the twisted turban, a plantain bud, etc., until the finial is reached, itself almost always enriched with ornament of individual character, and surmounted by the gilt “ti,” which is hardly ever the same in two pagodas. A comparison between the Shwe Dagon in Rangoon, the Shwe-Tsan-Dau at Prome, and the unique bell pagoda at Bhamo will soon demonstrate this. Further, the treatment of the panels, which often lend interest to the plinth, the guardian leogryphs and votive vases, the emblematical tree rising from its architectural base, and the hundred odd architectural and artistic adjuncts which combine in forming any given pagoda are all as distinctive as are the different types of humanity. Moreover, each is beautiful, and far from being “sick of pagodas,” my only regret is that I had not sufficient time at my disposal more fully to study and analyze the undoubted charm each possesses. When to all this is added the effect of gilding in one case, and the subduing influence of age and weather in another, combined with an infinite variety of environment, the pagoda can never become monotonous, particularly when seen as principal object in a landscape of tropical richness, whose beauties are reflected in one of the noblest rivers in the world, and

bathed in an atmosphere which lends an enchantment to the whole.

The number and richness of these pagodas suggest another thought,—that the religion of the Burman is active and living, and though many of these buildings are the tangible expression of the piety of past generations, new pagodas and kyaungs are constantly springing up, while many existing shrines are annually being added to and enriched by devotees of the present day. Indeed, herein lies a danger. In the Shwe Dagon pagoda in Rangoon the religious enthusiasm of the pious has led to structural additions which have seriously impaired the beauty of the building, and the same thing is occurring in other places. It seems to me a pity that such acts of vandalism are not controlled, and I would very much like to see the institution in Burma of a department for the preservation of native monuments such as exists in Egypt, in whose hands would rest the restoration and protection of the best examples of native art, and whose duty it would be to guide the enthusiasm of present-day devotees into channels of usefulness, and prevent the addition of incongruous excrescences to buildings which are not only historic but architecturally complete.

It is not only in the building of pagodas or kyaungs that the Burman expresses his religious instinct. Every male Burman passes at least a small period of his life as an inmate of a monastery, and the practice of and belief in his faith is universal and evidently sincere; and there can be no doubt, I think, that to the influence of Buddhism is due much that is lovable in the character of the people, as well as the creation of an art at once beautiful and distinctive.

They are affectionate to their offspring, and show unbounded respect to their parents, while the unfettered freedom enjoyed by their women places the Burmese far above the generality of Eastern races. And even if the Burman is somewhat indolent and conceited, his indolence is largely that of the gentleman of leisure, while so much of grace and beauty envelops the conceit that we readily forgive it.

All in all, the Burmese are a people infinitely attractive, and when to-day so large a proportion of mankind is given up to ideas altogether material and utilitarian, it is surely something for which to be thankful that in Burma we can still find a country which is a garden of wonderful beauty, and inhabited by a race entirely in harmony with its surroundings, and who understand what is meant by the "joy of living."

HOW MAN HAS CHANGED THE FACE OF NATURE—IRRIGATION.

BY

CHARLES WELSH.

THE subject of "How Man Has Changed the Face of Nature," is a large one, and could only be covered by a complete survey of the earth and the history of man's relations to it, but a few facts in relation thereto may stimulate interest and evoke inquiry.

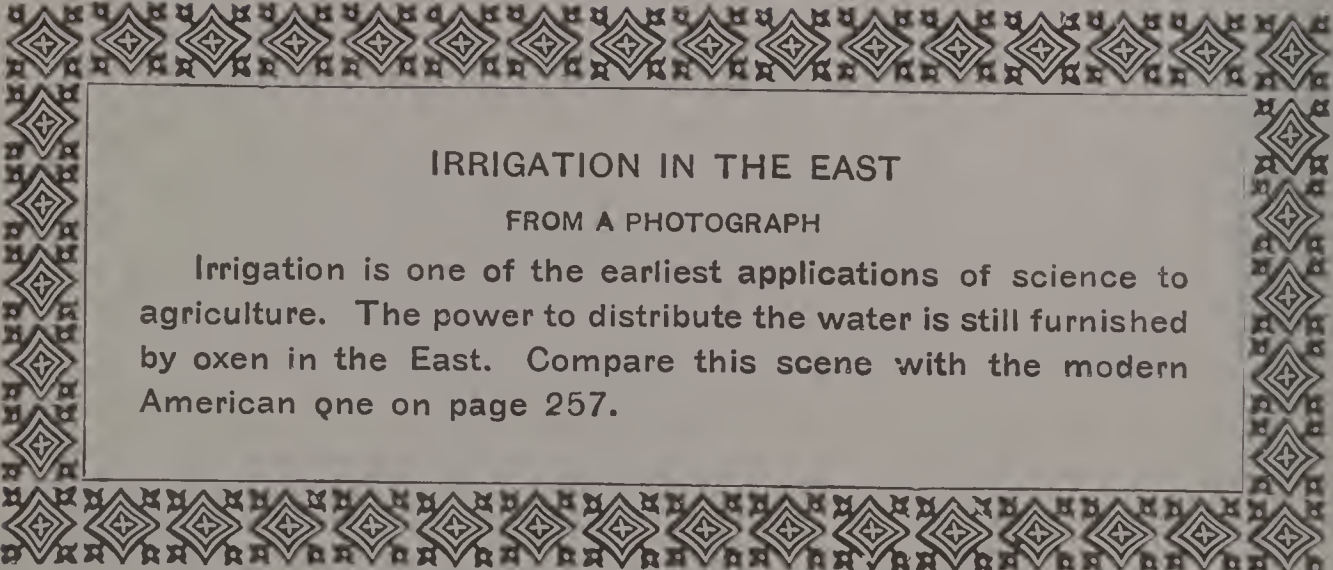
Nowhere has man left such traces of his handiwork upon the face of nature, and nowhere have these traces multiplied so rapidly, as in our own country. What was once a cow-path meandering through fields where Boston now is, is to-day Washington Street, one of the busiest shopping centres in the whole world, where thousands of buyers from hundreds of towns and villages round about, daily congregate.

The reclamation of marsh lands, the guiding of rivers into channels, along the banks of which cities have grown up, the clearing and settling of forest lands, the spreading of the net-work of railroads all over the country, with the towns growing up along their routes, all this has changed entirely the face of nature.

And it is to be hoped that re-afforestation will ere long change the face of the acres which have been ruthlessly denuded of their forest trees to furnish lumber for building and wood-pulp for paper-making.

But, of all the factors in the changing of the face of





IRRIGATION IN THE EAST

FROM A PHOTOGRAPH

Irrigation is one of the earliest applications of science to agriculture. The power to distribute the water is still furnished by oxen in the East. Compare this scene with the modern American one on page 257.

nature that have been in operation since the days when the waters of the Nile were first utilized to make the desert blossom like the rose, down to the present time, one of the greatest has been the development of the art and science of Irrigation. Man's conquest over the difficulties with which he found himself surrounded, was never more signally exemplified than in the Irrigation System which the people of the State of Utah have developed. Its soil is, as a rule, dry and sandy, and in many places useless for purposes of cultivation because of its strong salty impregnation. By Irrigation enormous tracts have been reclaimed and rendered profitably productive so that the earth yields up fruit after its kind, and supports man and beast where dry desert was before.

In India, in Egypt, in Canada, in Australia, and New Zealand, the British people have made millions of acres productive that were formerly barren, and the appearance and prospects of the western third of the United States have been entirely changed by our own enterprise in this direction.

It is impossible within the space of this note to describe the various methods by which water is introduced above and below the soil for the purpose of rendering it fertile. The subject of Irrigation is now one of national importance—equal in importance to the care and preservation of our forests.

AN AVALANCHE.

BY

GEORGE B. CHEEVER, D. D.

WE were so very highly favored as to see two of the grandest avalanches possible in the course of about an hour, between twelve o'clock and two. One cannot command any language to convey an adequate idea of their magnificence.

From "Wanderings of a Pilgrim in the Shadow of Mont Blanc."

You are standing far below, gazing up to where the great disc of the glittering Alp cuts the heavens, and drinking in the influence of the silent scene around. Suddenly an enormous mass of snow and ice, in itself a mountain, seems to move; it breaks from the toppling outmost mountain ridge of snow, where it is hundreds of feet in depth, and in its first fall of perhaps two thousand feet, is broken into millions of fragments. As you first see the flash of distant artillery by night, then hear the roar, so here you may see the white flashing mass majestically bowing, then hear the astounding din. A cloud of dusty, misty, dry snow rises into the air from the concussion, forming a white volume of fleecy smoke, or misty light, from the bosom of which thunders forth the icy torrent in its second prodigious fall over the rocky battlements. The eye follows it, delighted, as it ploughs through the path which preceding avalanches have worn, till it comes to the brink of a vast ridge of bare rock, perhaps more than two thousand feet perpendicular. Then pours the whole cataract over the gulf, with a still louder roar of echoing thunder, to which nothing but the noise of Niagara in its sublimity is comparable.

Nevertheless, you may think of the tramp of an army of elephants, of the roar of multitudinous cavalry marching to battle, of the whirlwind tread of ten thousand bisons sweeping across the prairie, of the tempest surf of ocean beating and shaking the continent, of the sound of torrent floods, or of a numerous host, or of the voice of the Trumpet on Sinai, exceeding loud, and waxing louder and louder, so that all the people in the camp trembled, or of the rolling orbs of that fierce Chariot described by Milton,

“Under whose burning wheels
The steadfast empyrean shook throughout.”

It is with such a mighty shaking tramp that the Avalanche thunders down.

Another fall of still greater depth ensues, over a second similar castellated ridge or reef in the face of the mountain, with an awful, majestic slowness, and a tre-

mendous crash in its concussion, awakening again the reverberating peals of thunder. Then the torrent roars on to another smaller fall, till at length it reaches a mighty groove of snow and ice, like the slide down the Pilatus, of which Playfair has given so powerfully graphic a description. Here its progress is slower, and last of all you listen to the roar of the falling fragments, as they drop, out of sight, with a dead weight into the bottom of the gulf, to rest there forever.

Now figure to yourself a cataract like that of Niagara (for I should judge the volume of one of these avalanches to be probably every way superior in bulk to the whole of the Horse-shoe Fall), poured in foaming grandeur, not merely over one great precipice of 200 feet, but over the successive ridgy precipices of two or three thousand, in the face of a mountain eleven thousand feet high, and tumbling, crashing, thundering down, with a continuous din of far greater sublimity than the sound of the grandest cataract. Placed on the slope of the Wengern Alp, right opposite the whole visible side of the Jungfrau, we have enjoyed two of these mighty spectacles, at about half an hour's interval between them. The first was the most sublime, the second the most beautiful. The roar of the falling mass begins to be heard the moment it is loosened from the mountain; it pours on with the sound of a vast body of rushing water; then comes the first great concussion, a booming crash of thunders, breaking on the still air in mid heaven; your breath is suspended, as you listen and look; the mighty glittering mass shoots headlong over the main precipice, and the fall is so great, that it produces to the eye that impression of dread majestic slowness, of which I have spoken, though it is doubtless more rapid than Niagara. But if you should see the cataract of Niagara itself coming down five thousand feet above you in the air, there would be the same impression. The image remains in the mind, and can never fade from it; it is as if you had seen an alabaster cataract from heaven.

The sound is far more sublime than that of Niagara, because of the preceding stillness in those awful Alpine

solitudes. In the midst of such silence and solemnity, from out the bosom of those glorious glittering forms of nature, comes that rushing, crashing thunder-burst of sound! If it were not that your soul, through the eye, is as filled and fixed with the sublimity of the vision, as through the sense of hearing with that of the audible report, methinks you would wish to bury your face in your hands, and fall prostrate, as at the voice of the Eternal! But it is impossible to convey any adequate idea of the combined impression made by these rushing masses and rolling thunders upon the soul. When you see the smaller avalanches, they are of the very extreme of beauty, like jets of white powder, or heavy white mist or smoke, poured from crag to crag, like as if the Staubbach itself were shot from the top of the Jungfrau. Travellers do more frequently see only these smaller cataracts, in which the beautiful predominates over the sublime; and at the inn they told us it was very rare to witness so mighty an avalanche as that of which we had enjoyed the spectacle. Lord Byron must have seen something like it, when he and Hobhouse were on the mountain together. His powerful descriptions in "Manfred" could have been drawn from nothing but the reality.

"Ye toppling crags of ice,
Ye avalanches, whom a breath draws down,
In mountainous o'erwhelming, come and crush me!
I hear ye momentarily, above, beneath,
Crush with a frequent conflict: but ye pass,
And only fall on things that still would live;
On the young flourishing forest, or the hut
And hamlet of the harmless villager.
The mists boil up around the glacier; clouds
Rise curling far beneath me, white and sulphury,
Like foam from the roused ocean of deep hell."

THE MER DE GLACE.

BY

GEORGE B. CHEEVER, D. D.

THE first and principal excursion from Chamouny is generally that to the Mer de Glace. It is not at all difficult, but if you have fine weather, it gives you some of the most sublime experiences of mountain scenery you can meet with in all the regions of the Alps. You cross the meadows in the vale of Chamouny, step over the new-born, furious Arve, and climb the mountain precipices to the height of 2,000 feet, by a rough, craggy path, sometimes winding amidst a wood of firs, and sometimes wandering over green grasses. At Montanvert you find yourself on the extremity of a plateau, so situated, that on one side you may look down into the dread frozen sea, and on the other, by a few steps, into the lovely green vale of Chamouny! What astonishing variety and contrast in the spectacle! Far beneath, a smiling and verdant valley, watered by the Arve, with hamlets, fields and gardens, the abode of life, sweet children and flowers;—far above, savage and inaccessible crags of ice and granite, and a cataract of stiffened billows, stretching away beyond sight—the throne of Death and Winter.

From the bosom of the tumbling sea of ice, enormous granite needles shoot into the sky, objects of singular sublimity, one of them rising to the great height of 13,000 feet, seven thousand above the point where you are standing. This is more than double the height of Mount Washington in our country, and this amazing pinnacle of rock looks like the spire of an interminable colossal Cathedral, with other pinnacles around it. No snow can cling to the summits of these jagged spires; the lightning does not splinter them; the tempests rave round them; and at their base, those eternal drifting ranges of snow are formed, that sweep down into the frozen sea, and feed the perpetual, immeasurable masses of the glacier. Meanwhile, the laughing verdure, sprinkled with flowers,

From "Wanderings of a Pilgrim in the Shadow of Mont Blanc."

plays upon the edges of the enormous masses of ice—so near, that you may almost touch the ice with one hand, and with the other pluck the violet. . . .

The impetuous arrested cataract seems as if it were ploughing the rocky gorge with its turbulent surges. Indeed the ridges of rocky fragments along the edges of the glacier, called moraines, do look precisely as if a colossal iron plough had torn them from the mountain, and laid them along in one continuous furrow on the frozen verge. It is a scene of stupendous sublimity. These mighty granite peaks, hewn and pinnacled into Gothic towers, and these rugged mountain walls and buttresses,—what a Cathedral! with this cloudless sky, by starlight, for its fretted roof—the chaunting wail of the tempest, and the rushing of the avalanche for its organ. How grand the thundering sound of the vast masses of ice tumbling from the roof of the Arve-cavern at the foot of the glacier! Does it not seem, as it sullenly and heavily echoes, and rolls up from so immense a distance before, even more sublime than the thunder of the avalanche above us? We could tell better, if we could have a genuine upper avalanche to compare with it. But what a stupendous scene! “I begin now,” said my companion, “to understand the origin of the Gothic Architecture.” This was a very natural feeling; but, after all, it could not have been such a scene that gave birth to the great idea of that “frozen poetry” of the Middle Ages. Far more likely it was the sounding aisles of the dim woods, with their chequered green light, and festooned, pointing arches.

The colossal furrow of rocks and gravel along the edges of the ice at the shores of the sea are produced by the action of the frost and the avalanches, with the march of the glacier against the sides of the mountains. Nothing can be more singular than these ridges of mountain débris, apparently ploughed up and worked off by the moving of the whole bed of ice down the valley. Near the shore, the sea is turbid with these rocks and gravel; but as you go out into the channel, the ice becomes clearer and more glittering, the crevices and fissures deeper and



ALPINE SCENERY

1. Head of Lake Lucerne.
2. The way up Mount Righi.
3. Lucerne—with the Righi in the distance.

more dangerous, and all the phenomena more astonishing. Deep, blue, pellucid founts of ice-cold water lie in the opening gulfs, and sometimes, putting your ear to the yawning fissures, you may hear the rippling of the rills below, that from the bosom of the glacier are hurrying down to constitute the Arve, bursting furiously forth from the great ice-cavern in the valley.

This Mer de Glace is an easy and excellent residence for the scientific study of the glaciers, a subject of very great interest, formerly filled with mysteries, which the bold and persevering investigations and theories of some modern naturalists have quite cleared up. The strange movements of the glaciers, their apparent wilful rejection of extraneous bodies and substances to the surface and the margin, their increase and decrease, long remained invested with something of the supernatural; they seemed to have a soul and a life of their own. They look motionless and silent, yet they are always moving and sounding on, and they have great voices that give prophetic warning of the weather to the shepherds of the Alps. Scientific men have set up huts upon the sea, and landmarks on the mountains opposite, to test the progress of the icy masses, and in this way it was found that a cabin constructed by Professor Hugi on the glacier of the Aar, had travelled between the years 1827 and 1840 a distance of 4,600 feet. It is supposed that the Mer de Glace moves down between four and five hundred feet annually.

It is impossible to form a grander image of the rigidity and barrenness, the coldness and death of winter, than when you stand among the billows of one of these frozen seas; and yet it is here that nature locks up in her careful bosom the treasures of the Alpine valleys, the sources of rich summer verdure and vegetable life. They are hoarded up in winter, to be poured forth beneath the sun, and with the sun in summer. Some of the largest rivers in Europe take their rise from the glaciers, and give to the Swiss valleys their most abundant supply of water, in the season when ordinary streams are dried up. This is a most interesting provision in the economy of nature, for if the glaciers did not exist, those verdant valleys

into which the summer sun pours with such fervor, would be parched with drought. So the mountains are parents of perpetual streams, and the glaciers are reservoirs of plenty.

The derivation of the German name for glacier, *gletscher*, is suggested as coming not from their icy material, but their perpetual motion, from *glitschen*, to glide; more probably, however, from the idea of gliding upon their surface. These glaciers come down from the air, down out of heaven, a perpetual frozen motion, ever changing and gliding, from the first fall of snow in the atmosphere, through the state of consolidated grinding blocks of ice, and then into musical streams that water the valleys. First it is a powdery, feathery snow, then granulated like hail, and denominated *firn*, forming vast beds and sheets around the highest mountain summits, then frozen into masses, by which time it has travelled down to within seven thousand feet above the level of the sea, where commences the great ice-ocean that fills the uninhabited Alpine valleys, unceasingly freezing, melting, and moving down. It has been estimated by Saussure and others that these seas of ice, at their greatest thickness, are six or eight hundred feet deep. They are traversed by deep fissures, and as they approach the great precipices, over which they plunge like a cataract into the vales, they are split in all directions, and heaved up into waves, reefs, peaks, pinnacles, and minarets. Underneath they are traversed by as many galleries and caverns, through which run the rills and torrents constantly gathering from the melting masses above. These innumerable streams, gathering in one as they approach the termination of the glacier, rush out from beneath it, under a great vault of ice, and thus are born into the breathing world, full-grown roaring rivers, from night, frost, and chaos. . . .

This Sea of Ice, which embosoms in its farthest recesses a little living flower-garden, whither the bumblebees from Chamouny resort for honey, is also bordered by steep, lonely beds of the fragrant *Rhododendron*, or Rose of the Alps. This hardy and beautiful flower grows

from a bush larger than our sweet fern, with foliage like the leaves of the ivory-plum. It continues blooming late in the season, and sometimes covers vast declivities on the mountains at a great height, where one would hardly suppose it possible for a handful of earth to cling to the rocky surface. There, amidst the snows and ice of a thousand winters, it pours forth its perfume on the air, though there be none to inhale the fragrance, or praise the sweetness, save only "the little busy bees," that seem dizzy with delight, as they throw themselves into the bosom of these beds of roses.

Higher still on the opposite side of this great Ice-Sea, there are mountain slopes of grass at the base of stupendous rocky pinnacles, whither the shepherds of the Alps drive their herds from Chamouny, for three months' pasturage. They have no way of getting them there but across the dangerous glacier; and it is said that the passage is a sort of annual celebration, when men, women, and children go up to Montanvert to witness and assist the difficult transportation. When the herds have crossed, one peasant stays with them for the whole three months of their summer excursion, living upon bread and cheese, with one cow among the herd to supply him with milk. When he is not sleeping, he knits stockings, and ruminates as contentedly as the browsing cattle, his only care being to increase his store.

NIAGARA.

ITS ORIGIN, ITS PROGRESS, AND ITS FUTURE.

BY

JOHN TYNDALL.

A CONNECTED image of the origin and progress of the cataract is easily obtained. Walking northward from the village of Niagara Falls by the side of the river, we have to our left the deep and comparatively narrow gorge, through which the Niagara

From "Fragments of Science."

flows. The bounding cliffs of this gorge are from 300 to 350 feet high. We reach the whirlpool, trend to the northeast, and after a little time gradually resume our northward course. Finally, at about seven miles from the present falls, we come to the edge of a declivity, which informs us that we have been hitherto walking on tableland. At some hundreds of feet below us is a comparatively level plain, which stretches to Lake Ontario. The declivity marks the end of the precipitous gorge of the Niagara. Here the river escapes from its steep mural boundaries, and in a widening bed pursues its way to the lake which finally receives its waters.

The fact that in historic times, even within the memory of man, the fall has sensibly receded, prompts the question, How far has this recession gone? At what point did the ledge which thus continually creeps backwards begin its retrograde course? To minds disciplined in such researches the answer has been, and will be—At the precipitous declivity which crossed the Niagara from Lewiston on the American to Queenston on the Canadian side. Over this transverse barrier the united affluents of all the upper lakes once poured their waters, and here the work of erosion began. The dam, moreover, was demonstrably of sufficient height to cause the river above it to submerge Goat Island; and this would perfectly account for the finding by Sir Charles Lyell, Mr. Hall, and others, in the sand and gravel of the island, the same fluviatile shells as are now found in the Niagara River higher up. It would also account for those deposits along the sides of the river, the discovery of which enabled Lyell, Hall, and Ramsay to reduce to demonstration the popular belief that the Niagara once flowed through a shallow valley.

The physics of the problem of excavation, which I made clear to my mind before quitting Niagara, are revealed by a close inspection of the present Horseshoe Fall. We see evidently that the greatest weight of water bends over the very apex of the Horseshoe. In a passage in his excellent chapter on Niagara Falls, Mr. Hall alludes to this fact. Here we have the most copious and the most violent

whirling of the shattered liquid; here the most powerful eddies recoil against the shale. From this portion of the fall, indeed, the spray sometimes rises without solution of continuity to the region of clouds, becoming gradually more attenuated, and passing finally through the condition of true cloud into invisible vapor, which is sometimes re-precipitated higher up. All the phenomena point distinctly to the centre of the river as the place of greatest mechanical energy, and from the centre the vigor of the fall gradually dies away towards the sides. The Horseshoe form, with the concavity facing downwards, is an obvious and necessary consequence of this action. Right along the middle of the river the apex of the curve pushes its way backwards, cutting along the centre a deep and comparatively narrow groove, and draining the sides as it passes them. Hence the remarkable discrepancy between the widths of the Niagara above and below the Horseshoe. All along its course, from Lewiston Heights to its present position, the form of the fall was probably that of a horseshoe; for this is merely the expression of the greater depth, and consequently greater excavating power, of the centre of the river. The gorge, moreover, varies in width, as the depth of the centre of the ancient river varied, being narrowest where that depth was greatest.

The vast comparative erosive energy of the Horseshoe Fall comes strikingly into view when it and the American Fall are compared together. The American branch of the river is cut at a right angle by the gorge of the Niagara. Here the Horseshoe Fall was the real excavator. It cut the rock, and formed the precipice, over which the American Fall tumbles. But since its formation, the erosive action of the American Fall has been almost nil, while the Horseshoe has cut its way for 500 yards across the end of Goat Island, and is now doubling back to excavate its channel parallel to the length of the island. The river bends; the Horseshoe immediately accommodates itself to the bending, and will follow implicitly the direction of the deepest water in the upper stream. The flexures of the gorge are determined by those of the river

channel above it. Were the Niagara centre above the fall sinuous, the gorge would obediently follow its sinuosities. Once suggested, no doubt geographers will be able to point out many examples of this action. The Zambesi is thought to present a great difficulty to the erosion theory, because of the sinuosity of the chasm below the Victoria Falls. But, assuming the basalt to be of tolerably uniform texture, had the river been examined before the formation of this sinuous channel, the present zigzag course of the gorge below the fall could, I am persuaded, have been predicted, while the sounding of the present river would enable us to predict the course to be pursued by the erosion in the future.

But not only has the Niagara River cut the gorge; it has carried away the chips of its own workshop. The shale, being probably crumbled, is easily carried away. But at the base of the fall we find the huge boulders already described, and by some means or other these are removed down the river. The ice which fills the gorge in winter, and which grapples with the boulders, has been regarded as the transporting agent. Probably it is so to some extent. But erosion acts without ceasing on the abutting points of the boulders, thus withdrawing their support and urging them gradually down the river. Solution also does its portion of the work. That solid matter is carried down is proved by the difference of depths between the Niagara River and Lake Ontario, where the river enters it. The depth falls from 72 feet to 20 feet, in consequence of the deposition of solid matter caused by the diminished motion of the river.

In conclusion, we may say a word regarding the proximate future of Niagara. At the rate of excavation assigned to it by Sir Charles Lyell, namely, a foot a year, five thousand years or so will carry the Horseshoe Fall far higher than Goat Island. As the gorge recedes it will drain, as it has hitherto done, the banks right and left of it, thus leaving a nearly level terrace between Goat Island and the edge of the gorge. Higher up it will totally drain the American branch of the river; the channel of which in due time will become cultivable land. The American

Fall will then be transformed into a dry precipice, forming a simple continuation of the cliffy boundary of the Niagara gorge. At the place occupied by the fall at this moment we shall have the gorge enclosing a right angle, a second whirlpool being the consequence. To those who visit Niagara a few millenniums hence I leave the verification of this prediction. All that can be said is, that if the causes now in action continue to act, it will prove itself literally true.

MOUNT SHASTA.

BY

T. M. HUTCHINGS.

THIS isolated and lofty volcanic mountain is located in latitude $41^{\circ} 30'$, and is the head and main source of the Sacramento, Shasta, and other streams. For many years it was considered the highest in California, and was estimated at 18,000 feet; more recent measurements, however, make it only about 13,000 feet. Being alone, and unconnected with any great mountain chains of the State, it seems to be the culminating crest or starting point of an independent range.

Covered with snow at all seasons of the year—the only one in the State that can be so considered—it is one of those glorious and awe-inspiring scenes which greet the traveller's eye, and fill his mind with wondering admiration, as he journeys among the bold and beautiful mountains of our own California. One almost wishes to kneel in worship as he gazes at the magnificent, snow-covered head and pine-girded base of this “monarch of mountains”; and even as you ascend the valley of the Sacramento, Mount Shasta appears to you like a huge mountain of snow just beyond the purple hills of the horizon; and is a constant landmark upon which to look, and which one unconsciously feels himself constrained to notice, as something even more remarkable and inviting than the green and flower-covered valley beside him.

From “Scenes of Wonder and Curiosity in California.”

As we are favored with the following graphic sketch of an ascent—alone—by Israel S. Diehl, we shall allow him, without comment, to relate his interesting narrative:

“The morning of the ninth of October, 1855, opened beautiful and bright; the earth had been cooled by refreshing showers which had copiously fallen during the night, as I took up my line of march from Yreka to Mount Shasta, to make its ascent, if possible.

“From the western side of Shasta Valley, Mount Shasta was in full view before me, in all its beauty and glory, as it reared its majestic head some seventeen thousand feet into the heavens, while its sides were covered with the deep-driven snow of ages, adding so much antiquity to the inspiring awe, as if to say, ‘I am the mighty monarch and sentinel of this western coast,’ and almost steadily did my unwearied, wondering eyes gaze admiringly upon the scene before me—hundreds of peaked little hillocks dotted the Shasta Valley for twenty-five miles around, like so many attendants (evidently all lesser volcanic formations), while the Shasta River, and other smaller streams, clear as crystal, and icy cold, sprang from its side.

“For a day and a half did I ride steadily on and around it, to make its ascent; all the time with the mountain in full view, and apparently but a little way off, deceiving even the best eye on calculation.

“For two nights, ere my ascent, did I watch the setting sun, with its purple rays lingering and playing for twenty or thirty minutes around its brow, when, to all other mountains, the sun had set. That scene was beautiful beyond description.

“By the noon of the second day, I had rounded the Mount to its south side, and fed my weary horse and self at the beautiful Strawberry Valley Rancho, or Gordon’s, after which, with indefinite and unsatisfactory directions, I bade adieu to every hope of seeing another person ere my fate became decided.

“For twelve or fifteen miles, I followed a blind snow trail through bushes of manzanita, and other obstacles, which almost threw me from my horse; and would surely

have torn my garments had I not been equipped with a good new suit of buckskin. After an arduous journey, I reached the upper edge of the belt of trees, and of the horse trail, but not until the sun had set. Night came on, rendering it too dark to find water for myself and animal until ten o'clock at night.

“Between shivering with cold, dozing, fearing, and dreaming, I awoke, and awaited the dawn of day. At last it came—gladly to me—when, after feeding my horse and bidding him adieu, I commenced the ascent.

“On the east side of the west spur, and the south side of the mountain, there were vast quantities of clink and volcanic stones, and for four weary hours I never set my foot off broken stone, but up, up, up, over rocks and stones, till I reached the base of an almost perpendicular ledge of rocks, the so-called Red Bluffs, which I found to be indurated clay, colored by the peroxide of iron. Through a little ravine I struggled on, on, climbing for one more painful hour, while large masses of rock, becoming loosened, went bounding to the awful abyss below.

“After reaching what I thought the desired summit, imagine my surprise to look over fields of lava, scoria, snow, and fearful glaciers. I now had to cross ravines or fissures, from fifty to one hundred feet deep, and from one hundred to three hundred feet wide, and worn through a solid mass of conglomerates, and sometimes half filled with snow and ice, the ice lying in perfect ridges, resembling the waves on the ocean, which were both sharp and dangerous to cross. I slipped and fell several times, once coming near being dashed thousands of feet below. After ascending for another hour, among this strangely mingled mass, hoping again to have reached the long desired summit, I was both disappointed and pleased to see the table-land of snow from one-fourth to one-half mile in diameter, where it lay from one hundred to probably one thousand and more feet deep, as I could look down into fissures where it had sagged apart, for a fearful depth, and from this field, a few hundred feet from the summit, the Sacramento River takes its rise; running through the deep gorges, sometimes on top, then

hidden, then appearing at the summit of hills, then concealed for miles, it breaks forth in magnificent springs and miniature rivers, with sulphur and soda springs intermixed.

“After crossing the field of ice with great difficulty, on account of the sun melting the snow from the east and south, while the wind and cold froze it from the west and north, thus rendering it dangerous, I reached another perfect mountain of loose and coarse lava, ashes, and other volcanic matter, through which I waded, although a foot in depth, for some distance; and as I ascended, I caught a full and first view of the actual summit, which I imagine is not seen from below, as it is a perfectly bare crag or comb of rocks, while the sides and top around are so covered as to hide the real summit. Across another field of snow, and I was evidently upon the original and main crater, a concavity covering several acres, almost hemmed in by a considerable rim of rocks, and here I came upon the long sought hot and sulphur springs; and here, free from wind and snow, finding it warm and comfortable after being nearly benumbed with cold, I warmed, and took a hasty meal; and in my haste to warm my fingers, nearly lost them by awfully scalding them.

“I spent nearly an hour here, contemplating and watching this wonderful view. A hundred little boiling springs were gurgling and bubbling up through a bed of sulphur, and emitting steam enough to drive a small factory (if well applied), while all around lay the everlasting snow.

“After resting, I made the final summit, a few hundred feet above, composed of a perfect edge or comb of rocks, running nearly north and south, and from this summit, perhaps the highest, variously estimated at from sixteen thousand five hundred, to seventeen thousand five hundred feet, and decidedly the most magnificent of our Union, if not of the continent, I could look around and see ‘all the kingdoms of this lower world.’

“Looking to the westward, far beyond the Scott, Trinity, Siskiyou, and Coast Range of mountains, I imagined

I saw the proud Pacific. Northward, looking far over into Oregon, one could see her peaks, her valleys, and lakes, to the Dalles, and what I took to be Mount Hood. East, far over the Sierras into Utah, and the deserts, while beautiful lakes lay like bright meadows, far in the distance. South, I could trace the Sacramento and Pitt Rivers, far below Shasta, where they were lost in the smoke and haze, but on the southwest I could clearly see Mount Linn, Mount St. John, and Ripley, and above the haze, could distinctly see the Marysville Buttes, if not the top of Mount Diablo (as I have clearly seen Mount Shasta from the summit of Mount Diablo). Southeast, I could trail the Sierras by the Lassen, Spanish, Pilot, Seventy-six, Downieville, and other peaks, to the range below Lake Bigler, or to Carson Valley.

“I contemplated the unsurpassed scenery presented to my eye, for hours. The day was clear and beautiful, after our first October rains, while the scenery was delightful beyond description. And upon that peak I planted the temperance banner, side by side with the American flag (placed there in 1852, by Captain Prince), deposited some California papers and documents in the rocks, for safe keeping, as the papers carried up in 1852 were unharmed, and fresh as ever. Then, with a great reluctance, notwithstanding the wind, cold, loneliness, and coming night, I was compelled to beat a descent.

“The sun was fast declining. My watch told three P.M., when I collected my minerals, sulphurs, and all objects of interest, for a future and fuller description, and bidding adieu to the magnificent sights, with a promise of a return some day I commenced the descent, and in three hours’ running, jumping, tumbling, sliding on the snow, from one-fourth to one-half a mile at a time, in a few moments—having a glorious time, easier by far, and fuller of enjoyment than the ascent—I found my horse, mounted, and hastened away; and after a concatenation of circumstances, lost and bewildered, at twelve at night, dismounted, unsaddled, and loosed my horse; weary and exhausted, nature gave way, sleep conquered, and until dawn of day, I knew no trouble save the piercing cold, and woke to find

my trusty horse missing, giving me a half day's hunt to recapture him, when, by perils by river, land, and Indians, I followed the Sacramento down one hundred miles to Shasta, to spend the Sabbath, after six days' labor—much better and happier for my ascent of Mount Shasta."

VESUVIUS.

BY

RICHARD A. PROCTOR.

IN the volcanic region of which Vesuvius or Somma is the principal vent, we have a remarkable instance of the deceptive nature of that state of rest into which some of the principal volcanoes frequently fall for many centuries together. For how many centuries before the Christian era Vesuvius had been at rest is not known; but this is certain, that from the landing of the first Greek colony in Southern Italy, Vesuvius gave no signs of internal activity. It was recognized by Strabo as a volcanic mountain, but Pliny did not include it in the list of active volcanoes. In those days, the mountain presented a very different appearance from that which it now exhibits. In place of the two peaks now seen, there was a single, somewhat flattish summit, on which a slight depression marked the place of an ancient crater. The fertile slopes of the mountain were covered with well-cultivated fields, and the thriving cities Herculaneum, Pompeii, and Stabiæ stood near the base of the sleeping mountain. So little did any thought of danger suggest itself in those times, that the bands of slaves, murderers, and pirates which flocked to the standards of Spartacus found a refuge, to the number of many thousands, within the very crater itself.

But though Vesuvius was at rest, the region of which Vesuvius is the main vent was far from being so. The island of Pithecusa (the modern Ischia) was shaken by

From "Light Science for Leisure Hours."

frequent and terrible convulsions. It is even related that Prochyta (the modern Procida) was rent from Pithecusa in the course of a tremendous upheaval, though Pliny derives the name Prochyta (or "Poured forth") from the supposed fact of this island having been poured forth by an eruption from Ischia. Far more probably, Prochyta was formed independently by submarine eruptions, as the volcanic islands near Santorin have been produced in more recent times.

So fierce were the eruptions from Pithecusa, that several Greek colonies which attempted to settle on this island were compelled to leave it. About 380 years before the Christian era, colonists under King Hiero of Syracuse, who had built a fortress on Pithecusa, were driven away by an eruption. Nor were eruptions the sole cause of danger. Poisonous vapors, such as are emitted by volcanic craters after eruption, appear to have exhaled, at times, from extensive tracts on Pithecusa, and thus to have rendered the island uninhabitable.

Still nearer to Vesuvius lay the celebrated Lake Avernus. The name Avernus is said to be a corruption of the Greek word Aornos, signifying "without birds," the poisonous exhalations from the waters of the lake destroying all birds which attempted to fly over its surface. Doubt has been thrown on the destructive properties assigned by the ancients to the vapors ascending from Avernus. The lake is now a healthy and agreeable neighborhood, frequented, says Humboldt, by many kinds of birds, which suffer no injury whatever even when they skim the very surface of the water. Yet there can be little doubt that Avernus hides the outlet of an extinct volcano; and long after this volcano had become inactive, the lake which concealed its site "may have deserved the appellation of 'atri janua Ditis,' emitting, perhaps, gases as destructive of animal life as those suffocating vapors given out by Lake Quilotoa, in Quito, in 1797, by which whole herds of cattle were killed on its shores, or as those deleterious emanations which annihilated all the cattle in the island of Lancerote, one of the Canaries, in 1730."

While Ischia was in full activity, not only was Vesuvius quiescent, but even Etna seemed to be gradually expiring, so that Seneca ranks this volcano among the number of nearly extinguished craters. At a later epoch, Ælian asserted that the mountain itself was sinking, so that seamen lost sight of the summit at a less distance across the seas than of old. Yet within the last two hundred years there have been eruptions from Etna rivalling, if not surpassing, in intensity, the convulsions recorded by ancient historians.

I shall not here attempt to show that Vesuvius and Etna belong to the same volcanic system, though there is reason not only for supposing this to be the case, but for the belief that all the subterranean regions whose effects have been shown from time to time over the district extending from the Canaries and Azores, across the whole of the Mediterranean, and into Syria itself, belong to but one great centre of internal action. But it is quite certain that Ischia and Vesuvius are outlets from a single source.

While Vesuvius was dormant, resigning for a while its pretensions to be the principal vent of the great Neapolitan volcanic system, Ischia, we have seen, was rent by frequent convulsions. But the time was approaching when Vesuvius was to resume its natural functions, and with all the more energy that they had been for a while suspended.

In the year 63 (after Christ) there occurred a violent convulsion of the earth around Vesuvius, during which much injury was done to neighboring cities, and many lives were lost. From this period shocks of earthquake were felt from time to time for sixteen years. These grew gradually more and more violent, until it began to be evident that the volcanic fires were about to return to their main vent. The obstruction which had so long impeded the exit of the confined matter was not, however, readily removed, and it was only in August in the year 79, after numerous and violent internal throes, that the superincumbent mass was at length hurled forth. Rocks and cinders, lava, sand, and scorïæ, were propelled from

the crater, and spread many miles on every side of Vesuvius.

We have an interesting account of the great eruption which followed in a letter from the younger Pliny to the younger Tacitus. The latter had asked for an account of the death of the elder Pliny, who lost his life in his eagerness to obtain a near view of the dreadful phenomenon. "He was at that time," says his nephew, "with the fleet under his command at Misenum. On August 24, about one in the afternoon, my mother desired him to observe a cloud of very extraordinary size and shape. He had just returned from taking the benefit of the sun, and, after bathing himself in cold water, and taking a slight repast, had retired to his study. He arose at once, and went out upon a height whence he might more distinctly view this strange phenomenon. It was not at this distance discernible from what mountain the cloud issued, but it was found afterwards that it came from Vesuvius. I cannot give a more exact description of its figure than by comparing it to that of a pine-tree, for it shot up to a great height in the form of a trunk, which extended itself at the top into a sort of branches; occasioned, I suppose, either by a sudden gust of air which impelled it, whose force decreased as it advanced upwards, or else the cloud itself, being pressed back by its own weight, expanded in this manner. The cloud appeared sometimes bright, at others dark and spotted, as it was more or less impregnated with earth and cinders."

These extraordinary appearances attracted the curiosity of the elder Pliny. He ordered a small vessel to be prepared, and started to seek a nearer view of the burning mountain. His nephew declined to accompany him, being engaged with his studies. As Pliny left the house, he received a note from a lady whose house, being at the foot of Vesuvius, was in imminent danger of destruction. He set out, accordingly, with the design of rendering her assistance, and also of assisting others, "for the villas stood extremely thick upon that lovely coast." He ordered the galleys to be put to sea, and steered directly to the point of danger, so cool in the midst of the turmoil

around "as to be able to make and dictate observations upon the motions and figures of that dreadful scene." As he approached Vesuvius, cinders, pumice-stone, and black fragments of burning rock, fell on and around the ships. "They were in danger, too, of running aground, owing to the sudden retreat of the sea; vast fragments, also, rolled down from the mountain and obstructed all the shore." The pilot advising retreat, Pliny made the noble answer, "Fortune befriends the brave," and bade him press onwards to Stabiæ. Here he found his friend Pomponianus in great consternation, already prepared for embarking and waiting only for a change in the wind. Exhorting Pomponianus to be of good courage, Pliny quietly ordered baths to be prepared; and "having bathed, sat down to supper with great cheerfulness, or at least (which is equally heroic) with all the appearance of it." Assuring his friend that the flames which appeared in several places were merely burning villages, Pliny presently retired to rest, and "being pretty fat," says his nephew, "and breathing hard, those who attended without actually heard him snore." But it became necessary to awaken him, for the court which led to his room was now almost filled with stones and ashes. He got up and joined the rest of the company, who were consulting on the propriety of leaving the house, now shaken from side to side by frequent concussions. They decided on seeking the fields for safety: and fastening pillows on their heads, to protect them from falling stones, they advanced in the midst of an obscurity greater than that of the darkest night—though beyond the limits of the great cloud it was already broad day. When they reached the shore, they found the waves running too high to suffer them safely to venture to put out to sea. Pliny "having drunk a draught or two of cold water, lay down on a cloth that was spread out for him; but at this moment the flames and sulphurous vapors dispersed the rest of the company, and obliged him to rise. Assisted by two of his servants, he got upon his feet, but instantly fell down dead; suffocated, I suppose," says his nephew, "by some gross and noxious vapor, for he al-

ways had weak lungs and suffered from a difficulty of breathing." His body was not found until the third day after his death, when for the first time it was light enough to search for him. He was found as he had fallen, "and looking more like a man asleep than dead."

But even at Misenum there was danger, though Vesuvius is distant no less than fourteen miles. The earth was shaken with repeated and violent shocks, "inso-much," says the younger Pliny, "that they threatened our complete destruction." When morning came, the light was faint and glimmering; the buildings around seemed tottering to their fall, and, standing on the open ground, the chariots which Pliny had ordered were so agitated backwards and forwards that it was impossible to keep them steady, even by supporting them with large stones. The sea was rolled back upon itself, and many marine animals were left dry upon the shore. On the side of Vesuvius, a black and ominous cloud, bursting with sulphurous vapors, darted out long trains of fire, resembling flashes of lightning, but much larger. Presently the great cloud spread over Misenum and the island of Capreæ. Ashes fell around the fugitives. On every side "nothing was to be heard but the shrieks of women and children, and the cries of men: some were calling for their children, others for their parents, others for their husbands, and only distinguishing each other by their voices: one was lamenting his own fate, another that of his family; some wished to die, that they might escape the dreadful fear of death; but the greater part imagined that the last and eternal night was come, which was to destroy the gods and the world together." At length a light appeared, which was not, however, the day, but the forerunner of an outburst of flames. These presently disappeared, and again a thick darkness spread over the scene. Ashes fell heavily upon the fugitives, so that they were in danger of being crushed and buried in the thick layer rapidly covering the whole country. Many hours passed before the dreadful darkness began slowly to be dissipated. When at length day returned, and the sun was seen faintly shining through the over-

hanging canopy of ashes, "every object seemed changed, being covered over with white ashes as with a deep snow."

It is most remarkable that Pliny makes no mention in his letter of the destruction of the two populous and important cities, Pompeii and Herculaneum. We have seen that at Stabiæ a shower of ashes fell so heavily that several days before the end of the eruption the court leading to the elder Pliny's room was beginning to be filled up; and when the eruption ceased, Stabiæ was completely overwhelmed. Far more sudden, however, was the destruction of Pompeii and Herculaneum.

It would seem that the two cities were first shaken violently by the throes of the disturbed mountain. The signs of such a catastrophe have been very commonly assigned to the earthquake which happened in 63, but it seems far more likely that most of them belong to the days immediately preceding the great outburst in 79. "In Pompeii," says Sir Charles Lyell, "both public and private buildings bear testimony to the catastrophe. The walls are rent, and in many places traversed by fissures still open." It is probable that the inhabitants were driven by these anticipatory throes to fly from the doomed towns. For though Dion Cassius relates that "two entire cities, Herculaneum and Pompeii, were buried under showers of ashes, while all the people were sitting in the theatre," yet "the examination of the two cities enables us to prove," says Sir Charles, "that none of the people were destroyed in the theatre, and indeed, that there were very few of the inhabitants who did not escape from both cities. Yet," he adds, "some lives were lost, and there was ample foundation for the tale in all its most essential particulars."

We may note here, in passing, that the account of the eruption given by Dion Cassius, who wrote a century and a half after the catastrophe, is sufficient to prove how terrible an impression had been made upon the inhabitants of Campania, from whose descendants he in all probability obtained the materials of his narrative. He writes that, "during the eruption, a multitude of men of super-

human stature, resembling giants, appeared, sometimes on the mountain, and sometimes in the environs; that stones and smoke were thrown out, the sun was hidden, and then the giants seemed to rise again, while the sounds of trumpets were heard"—with much other matter of a similar sort.

In the great eruption of 79, Vesuvius poured forth lapilli, sand, cinders, and fragments of old lava, but no new lava flowed from the crater. Nor does it appear that any lava-stream was ejected during the six eruptions which took place during the following ten centuries. In the year 1036, for the first time, Vesuvius was observed to pour forth a stream of molten lava. Thirteen years later, another eruption took place; then ninety years passed without disturbance, and after that a long pause of 168 years. During this interval, however, the volcanic system, of which Vesuvius is the main but not the only vent, had been disturbed twice. For it is related that in 1198 the Solfatara Lake crater was in eruption: and in 1302, Ischia, dormant for at least 1,400 years, showed signs of new activity. For more than a year earthquakes had convulsed this island from time to time, and at length the disturbed region was relieved by the outburst of a lava-stream from a new vent on the southeast of Ischia. The lava-stream flowed right down to the sea, a distance of two miles. For two months, this dreadful outburst continued to rage; many houses were destroyed; and although the inhabitants of Ischia were not completely expelled, as happened of old with the Greek colonists, yet a partial emigration took place.

The next eruption of Vesuvius occurred in 1306; and then three centuries and a quarter passed during which only one eruption, and that an unimportant one (in 1500), took place. "It was remarked," says Sir Charles Lyell, "that throughout this long interval of rest, Etna was in a state of unusual activity, so as to lend countenance to the idea that the great Sicilian volcano may sometimes serve as a channel of discharge to elastic fluids and lava that would otherwise rise to the vents in Campania."

Nor was the abnormal activity of Etna the only sign

that the quiescence of Vesuvius was not to be looked upon as any evidence of declining energy in the volcanic system. In 1538 a new mountain was suddenly thrown up in the Phlegræan Fields—a district including within its bounds Pozzuoli, Lake Avernus, and the Solfatara. The new mountain was thrown up near the shores of the Bay of Baiæ. It is 440 feet above the level of the bay, and its base is about a mile and a half in circumference. The depth of the crater is 421 feet, so that its bottom is only six yards above the level of the bay. The spot on which the mountain was thrown up was formerly occupied by the Lucrine Lake; but the outburst filled up the greater part of the lake, leaving only a small and shallow pool.

The accounts which have reached us of the formation of this new mountain are not without interest. Falconi, who wrote in 1538, mentions that several earthquakes took place during the two years preceding the outburst, and above twenty shocks on the day and night before the eruption. “The eruption began on September 29, 1538. It was on a Sunday, about one o’clock in the night, when flames of fire were seen between the hot-baths and tripergola. In a short time the fire increased to such a degree that it burst open the earth in this place, and threw up a quantity of ashes and pumice-stones, mixed with water, which covered the whole country. The next morning the poor inhabitants of Pozzuoli quitted their habitations in terror, covered with the muddy and black shower, which continued the whole day in that country—flying from death, but with death painted in their countenances. Some with their children in their arms, some with sacks full of their goods; others leading an ass, loaded with their frightened family, towards Naples. . . . The sea had retired on the side of Baiæ, abandoning a considerable tract; and the shore appeared almost entirely dry, from the quantity of ashes and broken pumice-stones thrown up by the eruption.”

Pietro Giacomo di Toledo gives us some account of the phenomena which preceded the eruption: “That plain which lies between Lake Avernus, the Monte Barbaro, and the sea, was raised a little, and many cracks were

made in it, from some of which water issued; at the same time the sea immediately adjoining the plain dried up about two hundred paces, so that the fish were left on the sand, a prey to the inhabitants of Pozzuoli. At last, on September 29, about two o'clock in the night, the earth opened near the lake, and discovered a horrid mouth, from which were furiously vomited smoke, fire, stones, and mud composed of ashes, making at the time of the opening a noise like the loudest thunder. The stones which followed were by the flames converted to pumice, and some of these were *larger than an ox*. The stones went about as high as a cross-bow will carry, and then fell down sometimes on the edge, and sometimes into the mouth itself. The mud was of the color of ashes, and at first very liquid, then by degrees less so; and in such quantities that in less than twelve hours, with the help of the above-mentioned stones, a mountain was raised of a thousand paces in height. Not only Pozzuoli and the neighboring country were full of this mud, but the city of Naples also; so that many of its palaces were defaced by it. This eruption lasted two nights and two days without intermission, though not always with the same force; the third day the eruption ceased, and I went up with many people to the top of the new hill, and saw down into its mouth, which was a round cavity about a quarter of a mile in circumference, in the middle of which the stones which had fallen were boiling up just as a cauldron of water boils on the fire. The fourth day it began to throw up again, and the seventh day much more, but still with less violence than the first night. At this time many persons who were on the hill were knocked down by the stones and killed, or smothered with the smoke."

And now, for nearly a century, the whole district continued in repose. Nearly five centuries had passed since there had been any violent eruption of Vesuvius itself; and the crater seemed gradually assuming the condition of an extinct volcano. The interior of the crater is described by Bracini, who visited Vesuvius shortly before the eruption of 1631, in terms that would have fairly represented its condition before the eruption of 79:—"The

crater was five miles in circumference, and about a thousand paces deep; its sides were covered with brushwood, and at the bottom there was a plain on which cattle grazed. In the woody parts, wild boars frequently harbored. In one part of the plain, covered with ashes, were three small pools, one filled with hot and bitter water, another salter than the sea, and a third hot, but tasteless." But in December, 1631, the mountain blew away the covering of rock and cinders which supported these woods and pastures. Seven streams of lava poured from the crater, causing a fearful destruction of life and property. Resina, built over the site of Herculaneum, was entirely consumed by a raging lava-stream. Heavy showers of rain, generated by the steam evolved during the eruption, caused in their turn an amount of destruction scarcely less important than that resulting from the lava-streams. For, falling upon the cone, and sweeping thence large masses of ashes and volcanic dust, these showers produced destructive streams of mud, consistent enough to merit the name of "aqueous lava" commonly assigned to it.

An interval of thirty-five years passed before the next eruption. But since 1666 there has been a continual series of eruptions, so that the mountain has scarcely ever been at rest for more than ten years together. Occasionally there have been two eruptions within a few months; and it is well worthy of remark that, during the three centuries which have elapsed since the formation of Monte Nuovo, there has been no volcanic disturbance in any part of the Neapolitan volcanic district save in Vesuvius alone. Of old, as Brieslak well remarks, there had been irregular disturbances in some part of the Bay of Naples once in every two hundred years:—the eruption of Solfatara in the twelfth century, that of Ischia in the fourteenth, and that of Monte Nuovo in the sixteenth; but "the eighteenth has formed an exception to the rule." It seems clear that the constant series of eruptions from Vesuvius during the past two hundred years has sufficed to relieve the volcanic district of which Vesuvius is the principal vent.

Of the eruptions which have disturbed Vesuvius during the last two centuries, those of 1779, 1793, and 1822, are in some respects the most remarkable.

Sir William Hamilton has given a very interesting account of the eruption of 1779. Passing over those points in which this eruption resembled others, we may note its more remarkable features. Sir William Hamilton says, that in this eruption molten lava was thrown up in magnificent jets to the height of at least 10,000 feet. Masses of stones and scorix were to be seen propelled along by these lava jets. Vesuvius seemed to be surmounted by an enormous column of fire. Some of the jets were directed by the wind towards Ottajano; others fell on the cone of Vesuvius, on the outer circular mountain Somma, and on the valley between. Falling, still red-hot and liquid, they covered a district more than two miles and a half wide with a mass of fire. The whole space above this district, to the height of 10,000 feet, was filled also with the falling and rising lava streams; so that there was continually present a body of fire covering the extensive space I have mentioned, and extending nearly two miles high. The heat of this enormous fire-column was distinctly perceptible at a distance of at least six miles on every side.

The eruption of 1793 presented a different aspect. Dr. Clarke tells us that millions of red-hot stones were propelled into the air to at least half the height of the cone itself; then turning, they fell all around in noble curves. They covered nearly half the cone of Vesuvius with fire. Huge masses of white smoke were vomited forth by the disturbed mountain, and formed themselves, at a height of many thousands of feet above the crater, into a huge, ever-moving canopy, through which, from time to time, were hurled pitch-black jets of volcanic dust, and dense vapors, mixed with cascades of red-hot rocks and scorix. The rain which fell from the cloud-canopy was scalding hot.

Dr. Clarke was able to compare the different appearances presented by the lava where it burst from the very mouth of the crater, and lower down when it had ap-

proached the plain. As it rushed forth from its imprisonment, it streamed, a liquid, white, and brilliantly pure river, which burned for itself a smooth channel through a great arched chasm in the side of the mountain. It flowed with the clearness of "honey in regular channels, cut finer than art can imitate, and glowing with all the splendor of the sun. Sir William Hamilton had conceived," adds Dr. Clarke, "that stones thrown upon a current of lava would produce no impression. I was soon convinced of the contrary. Light bodies, indeed, of five, ten, and fifteen pounds' weight, made little or no impression, even at the source; but bodies of sixty, seventy, and eighty pounds were seen to form a kind of bed on the surface of the lava, and float away with it. A stone of three hundredweight, that had been thrown out by the crater, lay near the source of the current of lava. I raised it up on one end, and then let it fall in upon the liquid lava, when it gradually sank beneath the surface and disappeared. If I wished to describe the manner in which it acted upon the lava, I should say that it was like a loaf of bread thrown into a bowl of very thick honey, which gradually involves itself in the heavy liquid and then slowly sinks to the bottom."

But as the lava flowed down the mountain slopes it lost its brilliant whiteness; a crust began to form upon the surface of the still molten lava, and this crust broke into innumerable fragments of porous matter called *scoriæ*. Underneath this crust—across which Dr. Clarke and his companions were able to pass without other injury than the singeing of their boots—the liquid lava still continued to force its way onward and downward past all obstacles. On its arrival at the bottom of the mountain, says Dr. Clarke, "the whole current," encumbered with huge masses of *scoriæ*, "resembled nothing so much as a heap of unconnected cinders from an iron foundry," "rolling slowly along," he says in another place, "and falling with a rattling noise over one another."

After the eruption described by Dr. Clarke, the great crater gradually filled up. Lava boiled up from below, and small craters, which formed themselves over the bot-

tom and sides of the great one, poured forth lava loaded with scorïæ. Thus, up to October, 1822, there was to be seen, in place of a regular crateriform opening, a rough and uneven surface, scored by huge fissures, whence vapor was continually being poured, so as to form clouds above the hideous heap of ruins. But the great eruption of 1822 not only flung forth all the mass which had accumulated within the crater, but wholly changed the appearance of the cone. An immense abyss was formed, three-quarters of a mile across, and extending 2,000 feet downwards into the very heart of Vesuvius. Had the lips of the crater remained unchanged, indeed, the depth of this great gulf would have been far greater. But so terrific was the force of the explosion that the whole of the upper part of the cone was carried clean away, and the mountain reduced in height by nearly a full fifth of its original dimensions. From the time of its formation the chasm gradually filled up; so that, when Mr. Scrope saw it soon after the eruption, its depth was reduced by more than 1,000 feet.

Of late, Vesuvius has been as busy as ever. In 1833 and 1834 there were eruptions; and in 1856 another great outburst took place. Then, for three weeks together, lava streamed down the mountain slopes. A river of molten lava swept away the village of Cercolo, and ran nearly to the sea at Ponte Maddaloni. There were then formed ten small craters within the great one. But these have since united, and pressure from beneath has formed a vast cone which has risen above the rim of the crater, from which torrents of lava are poured forth. At first the lava formed a lake of fire, but the seething mass found an outlet, and poured in a wide stream towards Ottajano. Masses of red-hot stone and rock are hurled forth, and a vast canopy of white vapor hangs over Vesuvius, forming at night, when illuminated by the raging mass below, a glory of resplendent flame around the summit of the mountain.

It may seem strange that the neighborhood of so dangerous a mountain should be inhabited by races free to choose more peaceful districts. Yet, though Herculaneum, Pompeii, and Stabiæ lie buried beneath the lava

and ashes thrown forth by Vesuvius, Portici and Resina, Torre del Greco, and Torre dell' Annunziata have taken their place; and a large population, cheerful and prosperous, flourishes around the disturbed mountain, and over the district of which it is the somewhat untrustworthy safety-valve.

[Since this was written the activity of Vesuvius has not abated, and it has from time to time continued to spread disaster and death—to the villages, towns, and cities which lie round about it—while the form of its summit has been entirely changed again.—C. W.]

THE CAVES OF CALAVERAS.

BY

T. M. HUTCHINGS.

THESE caves are situated about fourteen miles west of the mammoth trees, sixteen miles south, by the trail, from Moquelumne Hill, seven miles north, from Murphy's Camp, nine miles east of San Andreas, and near the mouth of O'Neil's Creek.

They were discovered accidentally, in October, 1850, by Captain Taylor, who, with others, was engaged in mining on this creek, and who, having finished their mid-day repast, were spending the interval, before resuming their afternoon's work, in shooting at a mark near the back of their cabin. Mr. Taylor, having just fired his rifle, proceeded to examine the mark, and having hit the centre, proposed that it should be placed at a greater distance than any at which they had ever before tried their skill; and was looking out for a tree upon which to place it, when he saw a hole among the rocks. He immediately went to it, and, seeing that the aperture extended into the mountain for some distance, he called to his companions, and they conjointly commenced to explore it.

The entrance is round a jutting angle of a ledge of rocks, which hides the small mining town adjacent from sight.

From "Scenes of Wonder and Curiosity in California."

Only the house of the proprietor is to be seen. The country around is wild and romantic. Provided with adamantine candles, we entered through a small doorway, which had been blasted out to a sufficient size. Thence we crept along twenty-five or thirty feet, threading our way through an irregular and difficult passage, at first descending rapidly, but afterward level. Sometimes we were forced to stoop, and at others to bend the body in accordance with the seam of the rocks which constitute the passage. Suddenly we emerged into a large vault or room, about sixty feet in length by twenty in breadth, with an irregular roof, running up in some places thirty feet. This room is called the Council Chamber. The walls are dark, rough, and solid, rather than beautiful. Descending a little to the southwest, we again made our way through a long, low passage, which led to another room of half the size of the Council Chamber. Rising from the floor of this room, by another narrow passage, we soon came into a third large room, of irregular construction. The roof ascends, until lost to sight in perfect darkness; here, as far up as the eye, assisted by the dim taper, can reach, the lime depositions present a perfect resemblance to a vast cataract of waters rushing from an inconceivable height, in a perfect sheet of foam, leaping from one great shelf of jutting rock down to others, onward, widening as they near, in exact perspective. This room is called the Cataract. And well does it deserve the name. Next we descended a short distance, by another passage, and entered a small, round room, in the centre of the roof of which runs up a lofty opening, sixty feet high, of singular appearance. This apartment is called the Cathedral. Turning back by the Cataract, we passed an easy way by a deep well of water upon the left, and very singular small pools or reservoirs on the right. Leaving these, we soon entered a spacious room, full one hundred feet square, and of fair proportionate height. Through another low opening, we entered yet another great room, near the centre of which stands a large, dark structure, the perfect likeness of a full-robed Roman Bishop, minus the head; whence the name for the

room, the Bishop's Palace. Descending through another small opening, we entered a room beautifully ornamented with pendants from the roof, white as the whitest feldspar, and of every possible form. Some like garments hung in a wardrobe, every fold and seam complete; others like curtains, with portions of columns, half-way to the floor, fluted and scalloped for unknown purposes; while innumerable spear-shaped stalactites, of different sizes and lengths, hung from all parts; giving a beauty and splendor to the whole appearance surpassing description. Once, as the light was borne up along a glorious fairy stairway, and back behind solid pillars of clear deposits, and the reflected rays glanced through the myriads of varying forms, the whole—pillars, curtains, pendants, and carved work, white as snow, and translucent as crystal—glistened and shone, and sparkled with a glory that surpassed in splendor all that we had seen in art, or read in fable. This is called the Bridal Chamber. Immediately at the back of this, and connected with it by different openings, is another room, now called Musical Hall. It is so called from the fact, that, on one side, suspended from a singular rock, that has the character of a musical sounding-board, hang a large number of stalactites, arranged in a line very large at one end, and gradually increasing in size toward the other, so that, if with a rod you strike the pendants properly, all the musical tones, from a common bass to a very high key, can be produced in perfection, ringing loud and clear through the halls, as a well-toned instrument.

THE NATURAL BRIDGES OF CALAVERAS.

BY

T. M. HUTCHINGS.

THESE bridges are situated on Cayote Creek on the Stanislaus River, and the entire water of Cayote Creek runs beneath them. The bold, rocky, and precipitous banks of the stream, both above and below

From "Scenes of Wonder and Curiosity in California."

the bridges, present a counterpart of wild scenery, in perfect keeping with the strange beauty and picturesque grandeur of their interior formation.

Approaching the upper bridge from the east, along the stream, the entrance beneath presents the appearance of a noble Gothic arch of massive stone-work, thirty-two feet in height, above the water, and twenty-five feet in width at the abutments; while the rock and earth above, supported by the arch, are thirty or more feet in thickness, and overgrown to some extent with trees and shrubbery.

Passing under the arch, along the border of the creek, the walls extend upward to an almost perfectly formed and pointed arch, and maintaining their width and elevation; but with here and there an irregularity, serving, however, to heighten the interest of the beautiful scene presented. Along the roof, or arch, hang innumerable stalactites, like opaque icicles, but solid as the limestone, or marble, of which they are formed.

As we advance, the width of the arch increases to nearly forty feet, and in its height to fifty feet; and here it really seems as though nature, in her playful moments, determined for once, in her own rude way, to mock the more elaborately-worked objects of art. Yet, as more in accordance with reality, we think that from such fine natural formation, the noble Gothic order of architecture was first suggested.

Here the spacious roof (with a little aid from the imagination) is made to resemble an immense cathedral, with its vaulted arches supported by innumerable columns along the sides, with here and there a jutting portion, as though an attempt had been made to rough-hew an altar, and corridor with massive steps thereto; while stalagmites, springing from the bottom and sides, would appear like waxen candles, ready to be lighted, but for the muddy sediment which has formed upon them.

Nor is this all, for near the foot of the altar is a natural basin of pure water, clear as crystal, as though purposely for a baptismal font.

Numerous other formations, some of them peculiarly

grotesque, and others beautiful, adorn the sides and roof of this truly magnificent subterranean temple; one of these, the "rock cascade," is a beautiful feature, as it bears a striking resemblance to that which would result from the instantaneous freezing, to perfect solidity, of a stream of water rolling down the rocky sides of the cavernous formation. Others resemble urns and basins; all formed from the action of, and ever filled to their brims with, clear cold water, as it trickles from the rocks above.

Approaching the lower section of this immense arch, its form becomes materially changed, increasing in width, while the roof, becoming more flattened, is brought down to within five feet of the water of the creek. The entire distance through or under this vast natural bridge is about ninety-five yards.

Nearly half a mile down the creek from the bridge described is another, with its arched entrance differing but little from the one already described, in size, but the form of the arch is quite different, being more flattened and broader at the top. Advancing beneath its wide-spreading arch, and passing another beautiful fount of water, issuing from a low, broad basin, wrought by nature's own hand, we arrive at a point where a roof and supporting walls present the appearance of a magnificent rotunda, or arched dome, sixty feet in width, but with a height of only fifteen feet.

Here, too, are numberless stalactites, hanging like opaque icicles from above, while the rocky floor, where the creek does not receive the trickling water from above, is studded thick with stalagmites of curious and beautiful forms. The length of this arch is about seventy yards.

These natural bridges give to the locality an interest exceeded by few in the State; they form the most remarkable natural tunnels known in the world, serving as they do for the passage of a considerable stream through them.

The entire rock formation of the vicinity is limestone, and various are the conjectures relative to the first formation of these natural bridges or tunnels; some believing them to have been formed by the rocky deposit

contained in, and precipitated by, the water of countless springs issuing from the banks of the creek, that, gradually accumulating and projecting, at length united the two sides, forming these great arched passages. Others believe that, as these bridges are covered many feet in depth with rock and earth, these natural tunnels were but so many subterranean passages or caverns, formed, we will not attempt to say *how*, but as other caverns are, or have been, in nearly all limestone formations; for were these subterranean passages to exist in the adjoining hills or mountains, with either one or two arches of entrance, they would be called caverns. But, by whatever freak of nature formed, they are objects of peculiar interest, and will repay the summer Rambler, among the mines and mountains, the trouble of visiting them.

ALABASTER CAVE—EL DORADO COUNTY.

BY

T. M. HUTCHINGS.

WHEN entering the cave from the road, we descend some three or four steps to a board floor. Here is a door that is always carefully locked, when no visitors are within. Passing on, we reach a chamber about twenty-five feet in length by seventeen feet in width, and from five feet to twelve feet six inches in height. This is somewhat curious, although very plain and uneven at both roof and sides.

Advancing along another passage, or room, several notices attract our eye, such as, "Please not touch the specimens," "No smoking allowed," "Hands and feet off" (with *feet* scratched out)—amputation of those members not intended! The low shelving roof, at the left and near the end of the passage, is covered with coral-like excrescences, resembling bunches of coarse rock-moss. This brings us to the entrance of the Dungeon of

From "Scenes of Wonder and Curiosity in California."

Enchantment. Before us is a broad, oddly-shaped, and low-roofed chamber, about one hundred and twenty feet in length by seventy feet in breadth, and ranging from four to twenty feet in height.

Bright coral-like stalactites hang down in irregular rows, and in almost every variety of shape and shade, from milk-white to cream-color; standing in inviting relief to the dark arches above, and the frowning buttresses on either hand; while low-browed ridges, some almost black, others of a reddish-brown, stretch from either side, between which the space is ornamented with a peculiar coloring that resembles a grotesque kind of graining.

Descending toward the left, we approach one of the most beautiful stalactitic groups in this apartment. Some of these are fine pendants, no larger than pipe-stems, tubular, and from two to five feet in length. Three or four there were, over eight feet long; but the early admitted Vandals destroyed or carried them off. Others resemble the ears of white elephants (if such an animal could be known to natural history), while others, again, present the appearance of long and slender cones, inverted.

By examining this and other groups more closely, we ascertain that at their base are numerous coral-like excrescences of great beauty; here, like petrified moss, brilliant, and almost transparent; there, a pretty fungus, tipped with diamonds; yonder, like miniature pine-trees, which, to accommodate themselves to circumstances, have grown with their tops downward. In other places, are apparent fleeces of the finest Merino wool, or floss silk.

Leaving these, by turning to the right we can ascend a ladder, and see other combinations of such mysterious beauty as highly to gratify and repay us. Here is the loftiest part of this chamber.

Leaving this, you arrive at a large stalagmite that resembles a tying-post for horses, and which has been dignified, or mystified, by such names as "Lot's wife" (if so, she was a very dwarf of a woman, as its altitude is but

four feet three inches, and its circumference, at the base, three feet one inch), “Hercules’ club,” “Brobdignag’s forefinger,” etc.

Passing on, over a small rise of an apparently snow-congealed or petrified floor, we look down into an immense cavernous depth, whose roof is covered with icicles and coral, and whose sides are draped with jet. In one of these awe-giving solitudes is suspended a heart, that, from its size, might be imagined to belong to one of a race of human giants.

On one side of this is an elevated and nearly level natural floor, upon which a table and seats have been temporarily erected, for the convenience of choristers, or for public worship. It would have gratified us beyond measure to have heard these “vaulted hills” resound the symphonies of some grand anthem from Mozart, or Haydn, or Mendelssohn. Many of the pendent harps would have echoed them in delicious harmonies from chamber to chamber, and carried them around, from roof to wall, throughout the whole of these rock-formed vistas.

We must not linger here too long, but enter other little chambers, in whose roofs are formations that resemble streams of water that have been arrested in their flow, and turned to ice. In another, a perfectly formed beet, from one point of view; and from another, the front of a small elephant’s head. A beautiful bell-shaped hollow, near here, is called “Julia’s bower”!

Advancing along a narrow, low-roofed passage, we emerge into the most beautiful chamber of the whole suite, entitled the Crystal Chapel. It is impossible to find suitable language or comparisons with which to describe this magnificent spot. From the beginning, we have felt that we were almost presumptuous in attempting to portray these wonderful scenes; but, in the hope of inducing others to see, with their natural eyes, the sights that we have seen, and enjoy the pleasure that we have enjoyed, we entered upon the task, even though inadequately, of giving an outline—nothing more. Here, however, we confess ourselves entirely at a loss.

The sublime grandeur of this imposing sight fills the

soul with astonishment, that swells up from within as though its purpose was to make the beholder speechless—the language of silence being the most fitting and impressive, when puny man treads the great halls of nature. . . .

After the mind seems prepared to examine this gorgeous spectacle somewhat in detail, we look upon the ceiling, if we may so speak, which is entirely covered with myriads of the most beautiful of stone icicles, long, large, and brilliant; between these are squares, or panels—the mullions or bars of which seem to be formed of diamonds; while the panels themselves resemble the frosting upon windows in the very depth of winter; and even these are of many colors—that most prevailing being of a light pinkish-cream. Moss, coral, floss, wool, trees, and many other forms adorn the interstices between the larger of the stalactites. At the farther end is one vast mass of rock resembling congealed water, apparently formed into many folds and little hillocks; in many instances connected by pillars with the roof above. Deep down, and underneath this, is the entrance by which we reached this chamber.

At our right stands a large stalagmite, dome-shaped at the top, and covered with beautifully undulating and wavy folds. Every imaginable gracefulness possible to the most curiously arranged drapery is here visible, “carved in alabaster” by the Great Architect of the universe. This is named “The Pulpit.”

In order to examine this object with more minuteness, a temporary platform has been erected, which, although detracting from the general effect, in our opinion, affords a nearer and better view of all these remarkable objects in detail.

This spectacle, as well as the others, being brilliantly illuminated, the scene is very imposing, and reminds one of those highly-wrought pictures of the imagination, painted in such charming language, and with such good effect, in such works as the “Arabian Nights.”

Other apartments, known as the “Picture Gallery,” etc., might detain us longer; but, as they bear a striking

resemblance, in many respects, to other scenes already described, we must take our leave.

AT THE WORLD'S END.

BY

ERNST HAECKEL.

THE extensive and uninhabited plain which stretches south of Newera Ellia to the very rim of the great central plateau of the island of Ceylon, and of which the isolated station of Hackgalla marks the northern limit, is called Horton's Plain, in honor of its discoverer, Lord Horton. The larger part of it is still covered with primæval forest, alternating with dry or marshy meadows known as patenas. Leopards, bears, and wild elephants are the sovereigns of this domain. The undulating surface of the plateau is intersected by numerous streams, between which the ground forms low hills, with here and there a loftier peak rising to seven or eight thousand feet above the sea. The southern edge ends almost everywhere in a steep cliff, and the wildest portion of the precipice is known by the characteristic name of The World's End. The rocky wall here falls abruptly—looking quite perpendicular—for about five thousand feet; and from the top the view is grand, over the rich forests of the southern lowlands, which spread for miles at its foot. This wonderful place is said to be the wildest part of the island, and is rarely visited by Europeans.

Not far from this romantic spot, in the heart of the wilderness, stands an uninhabited hut, built with thick stone walls, which was erected by the government as a refuge for officials who might be obliged to travel hither—Horton's Plain rest-house. Dr. Trimen and I proposed to spend a week here, making excursions into the neighboring wilderness, which had never yet been visited. All our preparations were complete, the key of the rest-house

From "A Visit to Ceylon."

and a government permit were in our hands, and we set out from Hackgalla full of expectation, and in the best of humors, early on the 20th of February.

As we were obliged to take with us not only provisions for a week, but bedding, blankets, tents, arms, etc., as well as a quantity of paraphernalia and tins for collecting plants and animals, we were forced to have a train of twenty coolies to carry all this baggage. Besides these, we each had a body servant; and Dr. Trimen had brought several men from Peradenia to collect and preserve plants. These were Cinghalese, the others were mostly Malabars or Tamil coolies. With a cook and a guide, our party numbered in all no less than thirty souls. . . .

We had the loveliest spring weather all the day through, for if it had rained heavily we should have been in an evil plight.

The lonely path, rarely trodden, along which we marched, cut sometimes through the thick primæval forest and sometimes across the wide open patenas. These are sharply distinct. The tall, dry, reed-like grasses, which are the principal growth on the patenas, grow so close together, and their rhizomes form such a compact and impenetrable flooring of roots, that they fairly defy all the giants of the forest in the struggle for existence; and every germ which may attempt to grow from the myriad seeds which must fall among the grass is inevitably choked at once. One, and only one, tree occasionally triumphs in the fight, and solitary specimens are not unfrequently to be seen raising a tall trunk and a spreading dark-green crown of foliage above the patenas; this is the mountain myrtle, with a poisonous pear-shaped fruit. Almost all the grasses afford but a wretched pasture for cattle; they are remarkable for their hard, dry, scabrous leaves, and angular stiff stems, some have, too, a distinctly aromatic smell.

The dense forest which breaks these patenas, forming, as it were, large irregular islands in the vast sea of grass—as in the prairies of North America—have the gloomy and sinister aspect which characterizes all these mountain forests, from Adam's Peak to Peduru (or

Pedro Talla Galla). Although the trees are actually of many various genera and species, they have a singular monotony of physiognomy, and as they often fail to perfect their flowers and fruit, it is really very difficult to distinguish them. Their leaves are usually leathery, dark green or blackish above, and often lustrous; the undersides lighter, and grayish, silvery, or rusty red. Their trunks are large and gnarled, sometimes completely clothed in yellow mosses and lichens, and overgrown with masses of parasitic plants, among which orchids and leguminous plants are conspicuous for the gaudiness of their flowers.

Horton's Plain rest-house stands on the same level above the sea as the top of Adam's Peak—7,200 feet; about a thousand feet above the *cirque* of Newera Ellia. The ascent lies principally within the second half of the way; the first half is up and down the gentle slopes of an undulating plain. About half way we came upon an empty bamboo hut, which had been erected some time before by a hunting party, and here we rested for an hour at midday. Excepting a few tumbling mountain streams, which we passed on tree-trunks thrown across them, the road offered no particular difficulties.

When we reached the top of the plateau, after climbing to the top of a deep ravine, down which a fine cataract fell, we came upon the characteristic Nilloo scrub, the favorite haunt of the wild elephants.

The Nilloo jungle, which I here saw more extensively distributed and developed than anywhere else, constitutes a very peculiar growth, and derives its name from various species of a genus of the *Acanthacæ*, all known to the natives as Nilloo. They are the favorite food of the elephant, and grow in thick sheaves with slender weak stems to a height of fifteen to twenty feet, with handsome spikes of flowers at the top. The finest of all is conspicuous by the splendid crimson red of its stem and flower bracts, and as these plants grow in dense masses, forming the whole underwood of the mountain forests, the effect under the level rays of the setting sun is indescribably gorgeous. The elephants steadily eat their way through

this Nilloo scrub; one marching close at the heels of another. Every bush that is not devoured is trodden flat; and where a herd of twenty or thirty of these colossal beasts have marched in single file through the wood, an open road of some yards wide is left ready beaten, as good as heart can desire—in a wilderness. In fact, these elephant tracks were the only paths we used during the expeditions of the next few days, and by following them alone we made several very interesting excursions. To be sure these convenient paths are not devoid of danger; for if the intruder should suddenly meet a herd of elephants, escape would be impossible, and it is necessary to keep a bright lookout.

The sun was set, and it was very dark by the time we emerged from the last patch of forest on to the open patena, within a mile of the longed-for rest-house. Fresh courage sprang up in the weary party, some of whom were indeed quite exhausted; and we still had a deep hollow to go down and up again, before we could reach the rest-house on the further side. A torrent foamed down the centre, which, for lack of a bridge, had to be crossed on a tree-trunk. We were heartily glad when the whole troop had succeeded in getting safely over this dangerous bit in the darkness and we had reached our destination.

The weather continued fine during our stay at Horton's Plain, and favored the interesting excursions which we made in various directions through this remote solitude. The fresh mountain air was wonderfully invigorating; but our miserable skin, which the equable moist heat of the lowlands had made very tender, suffered severely. On our hands and faces it cracked as it does with us in a severe winter; partly in consequence of the extreme drought of the rarer air, partly from the severe changes of temperature. At noon the thermometer would rise to 30° or 33° Centigrade in the shade, while at midnight it fell to 4° or 5° C.* In the early morning the patenas were white with frost, and a thick mist lay over hill and dale; but it soon rolled off, giving way to a brilliant blue sky

* On the Centigrade thermometer, Freezing point is Zero, and Boiling point 100°. On the Fahrenheit, Zero is 32 degrees below Freezing point, and Boiling point, 212°, or 180° above Freezing point.

and glorious sunshine. In the afternoon, heavy clouds usually gathered, but it did not rain; they packed into fantastic masses, which the setting sun painted with glory.

It was not the weather only which here, at the end of February, reminded me of a fine late autumn in Europe; the whole mountain landscape, at the end of the dry season, had a marked autumnal aspect. The thick, coarse herbage of the patenas was parched and generally tawny yellow rather than green; indeed, wide patches of it were brown and black, and burnt to ashes. The Cinghalese mountain herdsmen, who come up here every year for a few months with their beasts, make a practice of setting these savannahs on fire at the end of the dry season, to improve the next crop of grass. Every evening we had the amusement of watching these extensive conflagrations, which spread to grand dimensions on the undulating slopes, or when they caught the dense woods which fringe the patenas. The writhing flames would creep in zigzags, like a fiery snake, up the hill-side; then suddenly rush across a level of dry grass and make a lake of fire, the sinister glow of which was reflected from the dim background of forest and the heavy masses of cloud overhead. Then hundreds of little white wreaths of steam rose up from the plain, as if geysers were bursting from the mountain-flank, and the shower of bright sparks they carried up with them, dancing and flashing, completed the illusion.

Though not an evening passed without our seeing this spectacle of prairie fires, we never caught sight of the Cinghalese herdsmen who originated them; the absolute solitude of the spot was unbroken by a single human creature.

The German poets are fond of singing the charms of "Waldeinsamkeit"—the solitude of nature—and we indemnify ourselves by its illusions for the numberless annoyances daily inflicted on us by the complications of civilized life. But what is our sophisticated "Waldeinsamkeit"—with a village a few miles away, at the best—to the real and immeasurable solitude which reigns in

this primæval wilderness of the Cinghalese highlands? Here, indeed, we are sure of being alone with inviolate nature.

The sense of utter loneliness which pervades these wilds is greatly heightened by the fact that the animals which inhabit them show scarcely any outward signs of life. The wild elephant is, no doubt, to this day the monarch of the forest, but once only did I ever see any; and the great Russa-deer, or elk, which is said not to be uncommon, and of which I often heard reports, I never saw at all. These and most other natives of the forest are, in fact, chiefly or exclusively nocturnal in their habits, and during the day remain hidden in the deep cool coverts. Even the great gray ape, which is very common here, I but rarely saw, though I often heard its gruff tones early in the morning.

The melancholy cries of some birds, particularly the green wood pigeons and bee-eaters, are rarely heard excepting in the early dawn; at a later hour the gaudy jungle cock is the only bird that breaks the silence. This gorgeous species appears to be nearly allied to the first parent of our domestic fowl. The male is conspicuous for his gay and brilliant plumage, fine orange brown ruff, and green sickle tail-feathers; while the hen is dressed in modest grayish brown. The sonorous call of this wild fowl, which is fuller and more tuneful than the crow of his farm-yard cousin, is often heard for hours in the wood, now near, now distant; for the rival males compete zealously in this vocal entertainment for the favor of the critical hens. I could, however, rarely get within shot, for they are so shy and cautious that the slightest rustle interrupts the performance, and when once I had fired a shot the forest was silent for a long time after.

I often sat painting for hours on some fallen tree-trunk without hearing a sound. Insects are as poorly represented as birds, and excepting ants, they are singularly scarce; butterflies and beetles occur in small variety, and are for the most part inconspicuous. The murmuring hum of a cloud of small flies, with the accompanying murmur of a forest rivulet, or the soft rustle of the wind in

the branches, is often the only sound that defies the deep silence of the Spirit of the mountain.

This adds to the weird impression produced by the fantastical forms of the trees of the primæval forest, the gnarled and tangled growth of their trunks and the forked boughs, bearded with yard-long growths of orange mosses and lichens, and robed with rich green mantles of creepers. The lower part of the tree is often wreathed with the white or strangely colored flowers of fragrant epiphytal orchids, while their dark-green crowns are gay with the blossoms of parasitic plants of various species. A highly characteristic ornament of these woods is the elegant climbing bamboo. Its slender grassy stems creep up the tallest trees, and hang down from the branches in long straight chains, elegantly ornamented with coronas of light-green leaves. But here, and everywhere else in the hill country, the most decorative plant is the magnificent *Rhododendron arboreum*, with its great branches of bright-red blossoms. Next to this, the most remarkable trees of these forests are species of laurel and myrtle. We miss all the forms common in the European woods, and especially firs; this important family is entirely absent from Ceylon.

The finest mountain panorama which we saw in the course of our expeditions about Horton's Plain, was from the summit of Totapella, which we ascended on February the 22d, in the most glorious weather. This peak is 7,800 feet above the sea level, and near the eastern limit of the plateau. From the top, which is little wooded and overgrown with the fine red-flowered *Osbeckia buxifolia*, there is an extensive view on every side: northwards, to the heights of Newera Ellia, Peduru, and Hackgalla; eastwards, over the hill country of Badoola and the peak of Namoonna; southwards, past the boundary cliffs of the World's End; and westwards, to Adam's Peak. The way up to the summit would have been in many places impenetrable, but for the elephant-tracks that we followed; where these were wanting, the coolies had to cut a path through the thick and tangled brushwood.

On the 24th, we made our way to the spot itself known

as the World's End; a famous, but rarely visited ravine, where the southern edge of the great tableland is cut off in a perpendicular wall five thousand feet high. The stupendous effect of this sudden fall is all the more startling, because the wanderer comes upon it after walking for a couple of hours through the forest, emerging immediately at the top of the yawning gulf at his feet. The rivers far below wind like silver threads through the velvet verdure of the plain, and here and there, by the aid of a telescope, a bungalow can be discovered in its plantation. Waterfalls tumble from the top of the ravine, which is overgrown with fine tree-ferns, and like the Staubbach at Lauterbrunnen, vanish in mist before they reach the bottom.

It was in this spot, the wildest and most unfrequented perhaps in all Ceylon, that, for the first and only time, I saw wild elephants in a state of nature, though I had already seen them as prisoners in the Corral, at the elephant hunt of Lambugana. My attention was first attracted by the crackle of breaking boughs in the heart of the underwood, at about fifty or sixty feet below the projecting rock on which I was standing. By watching carefully I could make out among the swaying greenery of the jungle a herd of ten or twelve elephants, taking their breakfast very much at their ease. There was little to be seen of them but the top of their heads and their trunks, with which they bent down and broke off the branches. After enjoying this unwonted sight for some time, and feeling secure in my elevated ambush, I fired off both the barrels of my rifle at the nearest of the elephants, but of course without wounding him, as my gun was only loaded with small shot. I was answered by the loud trumpeting, which is always the note of alarm when elephants are surprised; then there was a loud crash through the thicket, which the huge brutes trod down like reeds, and in a few minutes the herd had disappeared round an angle of the cliff.

From the World's End, which was also the end of our interesting expedition, we went down by a steep and winding path through the loveliest wooded gorges—a

walk of five hours—to Nonpariel, the first coffee plantation that we met with on descending from the mountain wilderness. It belongs to Captain Bayley, the same enterprising man whose pretty marine villa I had previously admired at Galle. I was most kindly received by his son, who acts as his head-bailiff. It had been our intention to go on the same afternoon to Billahooloya, the highest village in the valley; but when we proposed to start at four o'clock, after an excellent dinner, such a tremendous storm came on that we were glad to accept our kind host's pressing invitation to remain for the night.

The rain ceased at about five, and the evening was lovely. We went over the fine plantation, a model of arrangement and care, and took a walk in the beautiful dells. Hundreds of tiny cataracts, caused by the brief but violent rainfall, danced down the cliffs on every side. The wonderful vegetation which fills these narrow rifts glittered and shone; the creepers, which hung in garlands from tree to tree, once more excited our astonishment and delight, and nimble monkeys performed gymnastics along them.

THE TAJ MAHAL.

BY

SIR WILLIAM WILSON HUNTER.

“THE mausoleum stands on a raised marble platform, at each of whose corners rises a tall and slender minaret of graceful proportions and of exquisite beauty. Beyond the platform stretch the two wings, one of which is itself a mosque of great architectural merit. In the centre of the whole design the mausoleum occupies a square of 186 feet, with the angles deeply truncated so as to form an unequal octagon. The main feature in this central pile is the great dome, which swells

upward to nearly two-thirds of a sphere and tapers at its extremity into a pointed spire crowned by a crescent. Beneath it an enclosure of marble trellis-work surrounds the tomb of the princess and of her husband, the Emperor. Each corner of the mausoleum is covered by a similar though much smaller dome erected on a pediment pierced with graceful Saracenic arches. Light is admitted into the interior through a double screen of pierced marble, which tempers the glare of an Indian sky while its whiteness prevents the mellow effect from degenerating into gloom. The internal decorations consist of inlaid work in precious stones, such as agate, jasper, etc., with which every spandrel or salient point in the architecture is richly fretted. Brown and violet marble is also freely employed in wreaths, scrolls, and lintels to relieve the monotony of white wall.

“In regard to color and design, the interior of the Taj may rank first in the world for purely decorative workmanship; while the perfect symmetry of its exterior, once seen can never be forgotten, nor the aërial grace of its domes, rising like marble bubbles into the clear sky. The Taj represents the most highly elaborated stage of ornamentation reached by the Indo-Mohammedan builders, the stage in which the architect ends and the jeweler begins.

“In its magnificent gateway the diagonal ornamentation at the corners, which satisfied the designers of the gateways of Itimad-ud-doula and Sikandra mausoleums, is superseded by fine marble gables, in bold twists, strong and handsome. The triangular insertions of white marble and large flowers have in like manner given place to fine inlaid work. Firm perpendicular lines in black marble with well proportioned panels of the same material are effectively used in the interior of the gateway.

“On its top the Hindu brackets and monolithic architraves of Sikandra are replaced by Moorish carved arches, usually single blocks of red sandstone, in the kiosks and pavilions which adorn the roof. From the pillared pavilions a magnificent view is obtained of the Taj gardens below, with the noble Jumna River at their



1. The Taj Mahal.

FROM A PAINTING IN WATER COLORS BY A. H. HALLAM MURRAY

2. A Scene in Burma.

FROM A PAINTING IN WATER GOLORS BY R. TALBOT KELLY

further end, and the city and fort of Agra in the distance. From this beautiful and splendid gateway one passes up a straight alley shaded by evergreen trees cooled by a broad shallow piece of water running along the middle of the path to the Taj itself. The Taj is entirely of marble and gems. The red sandstone of the other Moham-medan buildings which used to form the thickness of the walls, is in the Taj itself overlaid completely with white marble, and the white marble itself inlaid with precious stones arranged in lovely patterns of flowers. A feeling of purity impresses itself on the eye and the mind from the absence of the coarser material which forms so invariable a material in Agra architecture. The lower wall and panels are covered with tulips, oleanders, and full-blown lilies, in flat carving on the white marble; and although the inlaid work of flowers done in gems is very brilliant when looked at closely, there is on the whole but little color, and the all-prevailing sentiment is one of whiteness, silence, and calm. The whiteness is broken only by the fine color of the inlaid gems, by lines in black marble, and by delicately written inscriptions, also in black, from the Koran. Under the dome of the vast mausoleum a high and beautiful screen of open tracery in white marble rises around the two tombs, or rather cenotaphs, of the Emperor and his princess; and in this marvel of marble the carving has advanced from the old geometrical patterns to a trellis-work of flowers and foliage, handled with great freedom and spirit. The two cenotaphs in the centre of the exquisite enclosure have no carving except the plain Kalamdan or oblong pen-box on the tomb of Emperor Shah Jehan. But both cenotaphs are inlaid with flowers made of costly gems, and with the ever graceful oleander scroll."

BY BAYARD TAYLOR.

"ON both sides the palm, the banyan, and the feathery bamboo mingle their foliage; the song of birds meets your ears, and the odor of roses and lemon flowers sweetens the air. Down such a vista and over such a foreground rises the Taj. There is no

mystery, no sense of partial failure about the Taj. A thing of perfect beauty and of absolute finish in every detail, it might pass for the work of Genii who knew naught of the weaknesses and ills with which mankind are beset."

BY MARK TWAIN.

"I SUPPOSE that many, many years ago I gathered the idea that the Taj's place in the achievements of man was exactly the place of the ice-storm in the achievements of Nature; that the Taj represented man's supremest possibility in the creation of grace and beauty and exquisiteness and splendor, just as the ice-storm represents Nature's supremest possibility in the combination of those same qualities. I do not know how long ago that idea was bred in me, but I know that I cannot remember back to a time when the thought of either of these symbols of gracious and unapproachable perfection did not at once suggest the other. If I thought of the ice-storm, the Taj rose before me divinely beautiful; if I thought of the Taj, with its encrustings and inlayings of jewels, the vision of the ice-storm rose. And so, to me, all these years, the Taj has had no rival among the temples and palaces of men, none that even remotely approached it—it was man's architectural ice-storm."

SUNRISE ON THE PARTHENON.

BY

THEODORE L. CUYLER,

PASTOR LAFAYETTE CHURCH, BROOKLYN, N. Y.

I HAVE enjoyed every hour in Athens. Last Tuesday I climbed Mount Pentelicus, and from its summit looked right down on the famous battlefield of Marathon. It is as smooth as a race-course, and so small that Miltiades with his ten thousand Athenians could cover

From "From the Nile to Norway and Homeward." New York. R. Carter & Brothers. Copyright. By permission.

the whole front against ten times as many Persians. On my way back I rode through groves of classic olive and pine, and green vineyards. It seemed as if I might meet Sophocles going out to meditate a new tragedy, or Anacreon to compose a new song for the vine-dressers. The air was instinct with the memories and glories of the past. This little land of Attica once ruled the world with its genius. On the ruins of that wonderful commonwealth—after long dark centuries of ignorance and obscurity—a new Athens and a new Greece have sprung up. No land on the Continent of Europe has a stronger claim on our hearts, or excites a more thrilling hope for its future than the land in which Pericles builded, and Plato thought, and Phidias carved, and Paul proclaimed the Gospel of eternal life.

At four o'clock yesterday morning I aroused my fellow-lodger at the Hôtel des Etrangers for a tramp up the Acropolis in time to catch the sunrise. The shadows were still lingering in the clefts of old Hymettus as we hurried across the open space between the Arch of Hadrian and the modest chapel of the American Mission. Rounding the hillside, we pass the ruined Theatre of Dionysius, with its forty carved marble seats—all empty. I would give something to know from which one of those tiers Socrates rose up to answer the gibes of the comedian. A little further on, we see the square-cut "Bema" from which Demosthenes once thundered. Let us be thankful that Lord Elgin could not kidnap that for the British Museum. The smooth roadway leads around the south side of the Acropolis and close by the rocky spur of Mars' Hill. We see the actual steps in the rock by which Paul went up, and the spot where he must have stood when, within ten minutes, he delivered the sublimest speech that ever stirred the air of classic Greece.

We had to hammer pretty loudly on the gate to arouse the porter who keeps the entrance to the Propylea. Those walls once trembled to a louder alarm, when the explosion of a magazine sent the columns of that splendid structure flying in the air. Powder seldom wrought more mischief; for that ascending vestibule of richly sculp-

tured Pentelic marble (which cost two millions of dollars and which was adorned with the statues of Phidias) was one of the marvels of Athenian magnificence. What a gorgeous spectacle it must have been when the Panathenaic procession swept up through that vestibule from the Sacred Way, with its trains of chariots and waving branches of the olive and the pine! Nearly a dozen of the Doric columns yet remain. Across the two central ones still hangs the solid lintel, twenty-two feet long and four feet in thickness. To have lifted that enormous block of marble to that position must have been no ordinary feat of engineering; but of far more interest to me than the columns is the pavement beneath them, worn smooth by the ceaseless tread of more than three and twenty centuries. Upon those identical slabs of white marble Pericles and Plato, Aristotle and Demosthenes have set their feet; the famous men of Rome—Cæsar, Pompey, Cicero, and Seneca—have trod there. Paul himself undoubtedly has walked there. The famous scholars of our times have gone in there. In fact, there is no other small spot on this round globe which has been pressed by the feet of so many of the mighty men of genius as the six square yards of that Portico of the Propylea.

We had no time to stop and moralize, for the sun was just beginning to peep over the northern end of Hymettus. A streak of his rays was touching the heights of Ægina and Salamis. At the eastern brow of the Acropolis the late Queen Amalia built up a "Bellevue," or platform of stonework, from which a view can be got sheer down into the modern city, which lies upon that side of the sacred mount. We hasten to that "coigne of vantage" and look westward. The first rays of the sun are just kindling on the brown columns of the Parthenon. They are browned now by the hand of Time and the storms of over twenty centuries; but what they were when Pericles first set them there, in their flashing splendor, what imagination can conceive or pen describe? It will always remain an enigma that within a single century Grecian art and philosophy should have flowered out in the most consummate of their productions of genius and then

straightway ceased to bloom again! All the greatest achievements of Athenian brains were wrought between the battles of Marathon and Cheronea, and that space does not cover more than the lives of a father and son, provided that they both lived seventy years. The only answer to this problem is that it seems to be God's plan to illuminate this world not by single stars, but by constellations.

After watching the golden sunlight for a few moments on the Parthenon, we walk on, amid heaps of broken columns and shattered friezes, to the northern brow of the Acropolis. A guard walks behind us, perhaps to see that we do not pocket a stray metope or triglyph; for since the Acropolis has been so plundered nobody is trusted there alone. A sly Britisher was detected, a while ago, in tossing rare bits of marble over the walls, which an accomplice was as slyly picking up down below. Let us be thankful, however, that neither Time nor Turk, nor Lord Elgin himself has ever succeeded in spoiling the exquisite northern colonnade and doorway of the Erechtheum. Those columns are the perfection of the Ionic order. The carvings around that "Gate Beautiful" are the consummate masterpiece of delicate Greek art. No human hands ever excelled that workmanship. There is a mass of exquisite moulding and of delicate "egg-and-anchor" ornamentation, that looks more like lacework cut in ivory than any carving of ordinary marble. All the finest Ionic structures in the world for the last two thousand years have been only the copies of what those Greek wonder-workers wrought on that end of that little Erechtheum within a single decade. They struck perfection at once, and all subsequent generations have done nothing but try to imitate their handiwork.

The rocky summit of the Acropolis is one mass of picturesque ruin. Of the forty-six superb columns of the Parthenon less than one-half are left standing. These are sadly marred; some of them snapped off in the middle. The broken fragments of the columns which were blown to pieces by the powder explosion caused by a Venetian bombshell, in 1687, lie scattered all over the

hill-top. I climbed over piles of sculpture on which the workmen of Pericles had made their eyes ache; but mine ached still worse to see such marvellous productions dashed into destruction. Yet, after all the havoc that time and storm and shell and invading enemies have wrought, the Parthenon and the Erectheum still remain as incomparably the most magnificent ruins on the face of the earth. The sun that shone on them yesterday morning has never yet shone on their equal.

But, while we are on the Acropolis, let us take a glimpse of the Athens which stretches around us to the north and east. There is a bright day-dawning of promise in this beautiful city, with its broad, clean streets, elegant Parisian mansions, in imitation of Attic architecture, and with its showy Academy, and University, and public schools. There are seventy thousand people here now. When Parliament is in session, there will be many more. Down in that plain building on the corner of Sophocles and Aristides Streets, the highest court of the city, still called the "Areopagus," will meet to-day. That large structure, surrounded by a fine park, is the Palace of King George the First.

While in cost, and adornment, it befits the modesty of a young kingdom, it contains some beautiful apartments. Upon its walls figures the fight at Navarino; and there are portraits of Capo D'Istria, and of Lord Byron who half redeemed the last months of his pitiable career by his devotion to the deliverance of Greece. Around the palace stretches a fine garden which is thrown open to the people every day.

Looking towards the Ilissus—which at this season is shrunk to a rivulet—we see the fourteen surviving columns of the Temple of Jupiter. When the whole one hundred and twenty-four were standing—crowned with their Corinthian capitals—that structure must have been one of the most magnificent on the globe. Not far from these imposing ruins is the ancient Stadium, on whose race-course the Olympic games were celebrated. It is six hundred feet in length and one hundred in breadth; we can still see the terraced sides on whose marble seats over

forty thousand Athenians once sat, and cheered the victors in the games. Paul had such encounters in his eye when he exhorted the racers for an heavenly crown to "so run that they might obtain."

Let us turn to the opposite side of the Acropolis, and below us, near the road to the Piræus, stands the Temple of Theseus—still in such perfect preservation that it scarcely shows the ravages of twenty centuries. As one looks at that exquisite Doric structure, with its columns and roof still complete, he can form some conception of what Athens must have been in the days of its matchless glory.

Of that ancient glory only a few other splendid fragments remain. The Parthenon is shattered. The stadium is deserted. Plato's Academy is now a private gentleman's garden. The tomb of Socrates no man knoweth to this day. But as I descended from the Acropolis, and passed by the immovable rock of Mars' Hill on which the great Apostle once stood, I said to myself,—“The glory of this world passeth away, but like that rock, the word of the Lord endureth forever!”

A VISIT TO KARNAK.

BY

T. G. APPLETON.

“But her choice sport was, in the hours of sleep,
To glide adown old Nilus, where he threads
Egypt and Ethiopia from the steep
Of utmost Axumé until he spreads,
Like a calm flock of silver-fleecèd sheep,
His waters on the plain,—and crested heads
Of cities and proud temples gleam amid,
And many a vapor-belted pyramid.”

SHELLEY—*“Witch of Atlas.”*

WE entered the vast open gate—one of the finest of those entrances to the temples which gave Thebes the epithet of the hundred-gated—but not city gates. There never was a wall to the city, and

From “A Nile Journal.” Boston. Roberts Bros.

these hundred gates admitted to what we can even now see to have been the grandest chain of temples, the scene of man's highest achievement in religious architecture. Though the Egyptians had the arch both round and pointed, the horizontal line was the inevitable expression of their genius. What a huge block was that which made the top of this doorway. How high hung in air, and how far grander was it all than the low, clumsy triumphal arch of Rome at its best! One's spirit was lifted to enter by such a portal. And then everywhere that profusion of figures on the surface, infinite simplicity and infinite detail. The avenue of sphinxes made no impression; so close together were they; so, as it were, beneath our feet; so mutilated, we could not judge them—we did not even try to do it; but when later, on a wall, we saw cut the flowing lines and majestic human face of a sphinx, we knew what they must have been. Soon, breathless with surprise, we stood in the great hall of Karnak. We could not look; we could only feel. So unaccustomed were we to such grandeur that we did not essay to take in the proportions of the temple, but sat amid this wreck of the Titans, and dreamily looked on and on, past many a fallen, many a standing, column, till our eye rested upon the sunshine of another temple-gate, so far away it seemed to be impossible that it should be a gate of Karnak.

Though we visited Karnak twice, we did not possess it. The unaccustomed nobleness of style—our ignorance of what each hall or colonnade might mean, and the cruel overthrow of these astonishing masses, made it impossible for our minds to possess them. When we again could review our Lepsius, our Martineau, our Wilkinson, we could with learned accuracy find the names for what we have seen, but sitting there, all was fused in the sentiment of ruined grandeur. And soon to know yet more ruin; in the first hall, every column but one had fallen; some slipped from the first drum and others incredibly snapped across, only one majestic survivor showing what they have been. I noticed that Nature, even when destructive, feels a touch of pity, and leaves for us enough beauty, with



1. The Ruins of the Great Temple at Karnak, on the Site
of the Ancient Thebes, Egypt. General View.

This is one of the most magnificent and wonderful of
Egyptian remains. One obelisk seen in the picture is 108
feet high.

2. The Parthenon.—East front.

This Temple of the "Virgin Goddess" was erected B.
C. 438, on the Acropolis, Athens, Greece, under the gen-
eral supervision of Phidias, the famous Greek Sculptor. It
was in good condition until 1687 when in the siege of
Athens by the Venetians it was blown up and nearly destroyed.

FROM PHOTOGRAPHS.

imagination's help, to complete the rest. We looked down with anger upon our slippery flooring, and almost hated the Nile for doing all this. He it is that sends his annual flood, baleful with poisonous nitre, to sap these columns the ages had spared for us, and soon must they all lie in dreadful confusion, while the wicked wave shall tear the beauty of their priceless lines. A sea-wall of burnt brick costing little, would, perhaps, save for us the beauty of Karnak. Let Christendom give the paltry sum, and see that the Khedive protects what the ages have entrusted to him. A certain picturesqueness, from the strange position of half-fallen columns, some standing inclined and golden against the blue sky, and some heavily resting upon the shoulders of their upright brothers, have an effect in utter contrast to the architect's intention.

After all, this architecture consists only of temples, with upright walls, or sometimes inclined, and colonnades of columns not lofty, their capitals but variations of the line of the bud and flower of the lotus and papyrus. In this rainless country they needed no steep roof, therefore the towering Gothic aisle was impossible, and the columns had to be close together for the flat slab to reach across. Light was not needed; it is in excess; and the old windows, of which we saw several examples, had heavy stone upright bars, but none across, for they needed not glass. Oddly enough, one of the first things we saw at Luxor was a cross; the meaning of it we did not know, but there it was, seeming to say—your cross is mine, for I planted the seed of the sublime ethics which, stolen and transplanted in Judea by Moses, in the fulness of time flowered into the loveliness of Christ. But the figures in the temples far surpassed in august beauty our expectations. They move before our eyes a procession of spirits stripped of materialism and fastuous color, friendly yet remote, half imparting and half hiding their secret. They all have the beauty of adolescents, and spring forward with an energy which is only suppressed. There is not a child or an old man among them; they are the ideal of human life—youthful manhood. The immor-

tal life of the hereafter blooms calm and everlasting upon each face, and their sweet close smile is the smile of present happiness; the brow is full, the eyes wide apart and heavy-lidded, their nose a delicate aquiline, their chin small and short. The whole countenance breathes spiritual loveliness, and even their great conquerors, from their chariots slaughtering and trampling their enemies, bend their bows, or wave their falchions, as in celestial calm; no frown disfigures their brows, and the same sweet smile we know so well is on their lips. They reminded me of the Apollo watching the flight of his arrows, only his grace is that of a phthisical dandy compared with these. And we saw the trains of captives, with the thongs about their wrists, made little, as men so situated feel, and at Medînet Haboo we saw those captive Jews who link this land with our Bible.

So, at last, saturated, overwhelmed, as if time had presented us with a goblet too heavy for our weak nerves, we returned, jaded and joyous, to our dahabeah. Groups of palms printed their feathery architecture against the sunset, to show us in this full Egypt how all Nature's hints had not been appropriated, while over the little lake at their feet, flights of silvery ibises circled mysteriously. It was the evening's and the Nile's hour of worship, and gladly from our divans we watched and shared it, continuing the new adoration we had found at Karnak. Almighty Amun Ra looked sweetly at us, and we became in soul Egyptians, and mystery floated to us from the far tomb of Medînet Haboo on the twilight, while glistening Nilus, darkening in his banks, counted his flocks of birds in chaplets, as beadsmen do their beads. And calm fell upon us out of Heaven, and we were at peace.

We divided our work into alternate days on either side of the river, and so the second day we visited the Colossi. We had to take donkeys twice, crossing a little arm of the Nile in a stupendous boat, consisting of irregular chunks of unpainted wood, and the oars crooked tree-boughs. And our ghostly, tattered oarsman might well have been the original Egyptian Charon taking us to the Elysian fields and the dead of old. It is still the con-

stant custom here for the dead to cross the Nile and be buried at home, and the old Egyptians always carried a corpse over an artificial lake, called the Lake of the Dead; and through these legends Charon first came from Greece to Italy.

We saw one of these boats, just at our boat's bow, starting with its freight of death. As the camel who bore the corpse was unladen, he lamented as never did hired mourner. They always wail and moan at the sight of a load; their cry might be called the burden of the Desert, in the sense the word is used in Holy Writ. The scrambling of the donkeys out of the boat on the Theban side was as funny as their getting in. A few sprang over, but mostly went piecemeal, or were hoisted over like infants. Soon we were proudly careering over the level plain with our obbligate suite of Scarabee-Arabs and bright little girls who ran by our side carrying water-pitchers for our lunch, and showing their faultless teeth, made whiter by their eyes of darkness. Of all gifts of bone or ivory which we could carry from Egypt we would most gladly take these pearly teeth; even the very mummies have them; no hot bread and sugary messes have spoiled for the earlier or later Egyptians their beautiful enamel. And so we rode through the streets of lupin, whose inexpressible green and whose enchanting odor struck our senses with delight, watched by the guardians of the plain and of the mystic city behind them.

These great Twin Brethren are the only statues in Egypt whose situation is perfection. Others are lost in rubbish, or crowded against fallen column or pylon, but these sit secure in their solitude with the purple mountains behind them, and gazing with their sightless eyes at their brethren of Karnak. Shattered, defaced, featureless, they still look with a regal placidity through the disfigurement which somehow still keeps this expression. And they are just far enough apart; their seventy feet of height measures the space between them; it gives them privacy in companionship. Their simplicity was utter, nor could rent or fissure destroy it. Eugenio and I both tried our hand at sketches. It was perhaps better

than writing our names upon the base, and yet so we should have been in illustrious company. Famous kings and heroes, from the golden days of Greece and Rome down to the persistent snob of our own time, are there all inscribed.

The music of Memnon, it is almost certain, was caused by the disruption of particles in its sandstone as the sun acted on the moisture of the night. An Arab clambered up the statue's back, and struck it with a stone, when it resounded musically.

After the Colossi, Medînet Haboo. The remains of temples here, less oppressively sublime than those of Karnak, had fascinations of their own. They were of the good period, and their cuttings had that beautiful precision and *netteté* which Rome vainly attempted to rival. Among the most charming things here in the long corridors were the blue ceilings of starry sky, still retaining their colors. The stars were all five-pointed, with three points on one side. And I stood where I could compare the blue of this sky with the real one beyond; they were wonderfully the same; the temple sky seemed a continuation of the one without.

MARRIAGE AMONG THE CLOVERS.

BY

GRANT ALLEN.

PLANTS marry and give in marriage just as truly as animals. They have their loves and their hatreds, their friendships and their enmities. The marriage customs of many among them are vastly interesting; and yet, in spite of all the attention that has been given to the subject of recent years, comparatively few people are even now aware how quaintly they pair, how varied and curious are their matrimonial arrangements. Most of us, it is true, have heard by this time the bare facts of the case—that flowers are mainly fertilized by the visits of insects; many of us even know that in the majority of instances the little golden dust

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which we call pollen must be transferred from the hanging bags on one blossom to the sensitive surface of another, or else seed will never be set; but not all of us are aware how intricate and how numerous are the minor devices by which each kind of plant effects this important object in its own fashion. I am going, therefore, in the present paper, to describe briefly the marriage customs of two alone among our commonest clovers, which I shall adduce as specimens of the strange variety to be found within the limits of a single type.

To begin with, however, I propose to examine, as a mere introduction, a couple of flowers of a well-known and dainty hot-house begonia, which may help us to the comprehension of the more plebeian clover-heads. Proverbial philosophy has long since taught us that "the longest way round is the shortest way home"; and when I drag in the begonia, which has apparently so little connection with the clover, and which is really about as unrelated to it by descent as two flowering plants can well be to one another, you may suspect that I do so for some sufficient reason. The fact is, begonias happen to be plants in which the differences of the sexes are exceptionally well marked, so that they may be apprehended with ease by the naked eye, and by every observer, even the most casual. I advise those who have conservatories of their own to verify my statements in this matter on the specimens in their possession.

Most cultivated begonias have the flowers on their branches arranged in groups or clusters of three, the central one of which is often a female, while the two outer blossoms are usually males. This is the ordinary plan, but it does not hold good of all the species, some of which, on the contrary, have only one male to each pair of females. Now, these male and female flowers are so very unlike in form and structure, when you come to look into them, that you would hardly believe they belonged to the same plant if you did not find them growing on one branch together. They differ quite as markedly as the peacock differs from the pea-hen, much more markedly than man differs from woman.

The first point of difference which you will note in the two is that the female begonia has five petals, while the male has four only. But what is more important than the number of the petals is the fact that the female flower has wedged at its back a large, triangular winged ovary, or seed-capsule. It is the possession of this ovary, indeed, that marks it out at once as a female: for by a female plant or animal we mean, of course, the one which lays the eggs, produces the seeds, or becomes the mother of the young individuals. If you compare the back of the female flower with the back of the male flower, you will recognize at once the importance of this distinction. The female blossom has a seed-bag, while the male is barren.

But this is not all: the other parts of the two flowers differ almost equally. The center of the female blossom is occupied by several twisted and wriggling arms, the upper surface of which is more or less sticky. This surface forms the receptive portion, or mouth of the flower, on which grains of pollen must be duly deposited before the embryo seeds in the capsule below can begin to swell and develop. On the other hand, the center of the male flower is occupied by a very different set of organs, the stamens, or pollen-bags, whose business it is to produce and shed the fertilizing powder. Without pollen to start them, the seeds are useless. In the wild state, any winged insect which visits the plant is likely to alight first on the lip or platform of one or the other of the outer male flowers. In his search for honey, which is secreted by the plant at the base of the petals on purpose to allure him, the flying visitor dusts himself over abundantly, though unconsciously, with grains of pollen from the very numerous little sacs which are placed there in a convenient situation with that precise object. He then flies away to the female flower, in which he alights, as a rule, on the central sticky portion (called by botanists the stigma): and, as he walks over it in search of the honey at the base of each petal, he turns himself round and round in five directions, and thus unwittingly rubs off the pollen which clings to his legs and hairs, transferring

it to the sticky and receptive surface. After visiting and fertilizing the female flower in the center in this manner, he then usually proceeds to visit the second brother beside it, from which he carries away pollen in turn to the next plant he visits. The object of this curious arrangement is that each flower may be fertilized by pollen from another blossom, and, as far as possible, at least by pollen from a distinct neighboring plant. But you will gather at once from what I have said already that each plant must be regarded in strictness not as an individual, but rather as a community or commonwealth, of which the leaves and flowers are the separate members told off to perform different duties. You may compare it, indeed, to a hive of bees, the leaves representing the workers, while the five-petaled flowers are analogous to the queen bees, and the four-petaled blossoms to the husbands or drones. Nay, more; those of my readers who have begonia plants of their own may observe for themselves another singular resemblance to the habits and manners of honey bees. For after the drones have done their work in life by fertilizing the queen bee, the prudent workers sting them to death as being useless mouths of no further benefit to the community; but the queen bee necessarily survives to become the mother of young swarms or future generations. If she were killed it would be all up with the community. Just so with the begonias; as soon as the male flowers have performed their whole duty in life by producing and disseminating the grains of pollen which the insects carry away and smear upon the sister blossoms, they break off at the joint and fall to the ground; the plant refuses to feed them any longer because it has now no use for them: but the fertilized female flowers remain fixed on their stems to produce the seeds from which will spring in time the future generations.

What, however, do I mean by fertilization? Well, each pollen grain, when closely examined under the microscope, looks like a tiny egg, with a very thin shell and a very sticky, active contents. As soon as the pollen grains are rubbed all over the curly branches in the center of the female flower, they empty their contents

down long tubes, which reach at last to the seeds; and under this vivifying influence, the seeds begin to swell and become capable of producing young plants. The pollen, in short, has quickening power. It is for the sake of this final result alone that the flowers exist; they are provided with bright colored petals as advertisements to let the insects know where honey may be expected; they secrete the sweet liquid itself in order to induce their winged allies to become common carriers of pollen for the benefit of the begonia; and as soon as each flower has served its purpose in this respect, it drops off or is retained by the plant according as it is or is not wanted in future for its seed producing properties.

To the clovers, then, which are our proper subject, I will next proceed. And I began with the begonia only by way of introduction, only because that afforded a case in which the husbands and wives of the community were so distinct from one another that nobody with a pair of eyes in his head could fail to distinguish them when they were once pointed out to him. In the clovers, on the other hand, we have a much more complicated arrangement, and one much less like the ordinary cases with which we are familiar in the animal world. Here the flowers are collected in heads or clusters, and each flower is in itself at once both male and female. This method, indeed, is common amongst plants; it occurs in by far the greater number of species; the reason why I started with the begonia is just because in that type the sexes are so well and clearly separated in distinct blossoms. In the clovers, however, each separate flower resembles a small pea blossom in shape, having four petals, which botanists name, respectively, from below upwards, the keel, the two wings, and the standard. They are enclosed beneath a small greenish calyx, or cup, and they contain within ten stamens, or pollen bags, as well as a tiny capsule like a miniature pea pod. At the tip of this capsule is a small hook—the sensitive surface on which the pollen has to be deposited. You would say at first sight that under such circumstances, male and female being mixed up in one, cross-fertilization must be impos-

sible—that each flower must surely be fertilized by its own pollen. But the clever clovers have invented an ingenious device of their own for overcoming this difficulty; the pollen bags and the sensitive surface of the capsule do not arrive at maturity together. In this way each flower or plant gets fertilized itself at one time by pollen from another plant, and at another time dusts the bee that visits it with its own pollen, which the bee transfers in due course to the next plant it visits.

The Dutch clover is a rather smooth specimen of its type, not nearly so hairy or silky as most other clovers, for a reason which I will explain a little later on; it has prostrate stems which creep along the ground, and root every now and again as they proceed, somewhat after the fashion of strawberry runners. Like all other clovers, it has trefoil leaves, each of the three leaflets in which is usually marked with a curved spot in the center resembling a horseshoe. But it is the flower heads with which I am here particularly concerned. These are raised on long, erect, leafless stems, each of which bears on its summit a globular head of little white pea flowers, often delicately tinged with pink or salmon. The flowers are thus lifted to a considerable height, because this clover grows, as a rule, among rather tall grasses, and so tries to push up its blossoms to a height where they may receive the polite attentions of passing insects.

The visitors for which Dutch clover specially lays itself out are for the most part bees. It disdains small pilferers. Each blossom has a long tube enclosing its honey, and only insects with a correspondingly long proboscis can reach its deep store of delicious nectar. It thus saves itself from being rifled uselessly by small insect riff-raff, such as flies and midges which might visit the flower, as we botanists call it, “illegitimately”—that is to say, might rob the honey without conveying the pollen from the pollen bags of one head to the sensitive surface or stigma of the next. The parts of the flower, in fact, are specially arranged with a definite relation to the head and honey sucking tube of hive bees and wild bees, which cannot visit it without dusting themselves

over with pollen on one blossom which they unconsciously rub off on the receptive surface of the next. In one word, Dutch clover encourages bees for its own purposes, because they are useful to it, while it places obstacles in the way of smaller and useless insects by burying its honey in a deep tube.

The florets or blossoms which make up the head begin opening from without and below, inward and upward. Thus the outer and lower florets have opened, while the inner and upper ones are still in bud. When a bee visits such a head of clover, he comes to it first from another head of the same kind, for bees do not usually mix their liquors; on one round of visits they confine themselves, as a rule, to a single species of flower only, and they probably store the honey of each kind in separate cells, just as we ourselves in our wine-cellars keep one bin for champagne, another for claret, and a third for Burgundy. The bee thus begins with the outer flower of the head, which he fertilizes with pollen from the last plant he visited; he then goes on to the second row, where he dusts himself over with pollen for another flower head; and the buds in the center he leaves severely unnoticed.

As soon as he flies away a very curious thing begins to happen. The flowers which he has unconsciously fertilized close over their seed vessel, and grow gradually brown or withered. At the same time they turn down out of the way of the bees by bending the separate little stalks on which they are raised in the head and tucking themselves tight against the common flower stem. This they do partly in order not to confuse and worry their allies the bees, but partly also to avoid certain other dangers to which I will recur later. Plants often try in such ways to save bees or butterflies time and trouble, because the easier they make matters for the bee or butterfly, the more likely he is to visit and fertilize them. He is a useful customer whom they desire to conciliate. If a bee on his rounds finds that any particular species of plant gives him unnecessary trouble in getting at his honey, he is apt to neglect it and pass it by in order to devote himself to other kinds which he sees are more business-

like and obliging. The moment he comes to a head of Dutch clover, then he knows at once that he may safely ignore the dry brown flowers tucked away against the stem, because they are already fertilized and honeyless; he therefore directs all his attention to the nature and open flowers which are now producing honey and ready for fertilization. These form practically, as you will see, at each moment the outer row of the flower head, and are the ones which naturally first engage his notice as he alights on the cluster. It sometimes takes four or five days for a single head to pass through all its stages.

You must bear in mind that none of this is true of the common purple clover, nor yet of the brilliant crimson kind (known to our farmers as "carnation trifolium"), both of which are distinct species with totally different marriage customs. The ingenious habit of turning the fertilized flowers downward, out of the way of the insects, is confined to a few species of white, pink and yellow clovers. It is a little dodge on which they happen to have hit, but which has not occurred to their larger and more conspicuous red and purple cousins. So if you try to follow out these hints in nature, you must be careful to hunt for the white kinds only.

Every kind of clover, owing to the richness of the seeds, is much exposed to the attacks of insect enemies. To baffle these wary foes the clovers have invented an extraordinary variety of protective devices, two of which I mean to examine in this essay. Dutch clover meets the difficulty by tucking down the flowers after fertilization out of the way of the bee, and then retaining the withered corolla or set of petals which completely enclose and hide the pod in the center. It is thus a distinct advantage to the clovers in the struggle for life that they have invented devices which enable them to guard their embryo young from the assaults of insects.

Every species of clover—and there are many—has some dodge of its own for thus protecting its growing pods and seeds from the grubs which would destroy them. I only propose, however, to examine in detail here one more of these dodges. We have another kind of clover,

a good deal like the Dutch clover at a casual glance and commonly confounded with it by unobservant people, though, as we shall see, the habits and manners of the two kinds are in reality very different. The strawberry clover, as it is called, is a somewhat lower and smaller species than the Dutch clover, which it resembles in its creeping stems and in its rich foliage. But the flowers are not separately stalked in the head, so that they cannot turn down after fertilization like those we have just been considering. Moreover, the stems and the flower heads are much hairier; and this difference is due to the two facts that the strawberry clover is smaller, and has a shorter tube than its Dutch relation. It would thus be easy for ants and other crawling insects to creep up the stem and steal the honey, which is intended for the use of fertilizing visitors. To prevent this misfortune and to keep its nectar for the regular customers, the strawberry clover produces a number of hairs on the stem, which baffle the ants, to whom such hairs are an impenetrable thicket. But you may ask, "Why are not ants just as good as bees for the clover?" For this reason: flying insects are mainly guided by sight and color; they flit straight from one flower to another of the same species; and their heads are exactly adapted to the shape of the flowers, which in turn have modeled their tubes and organs on purpose to fit them. Ants and creeping insects, on the contrary, are attracted merely by the sense of smell: they notice the scent of honey; they climb up all stems indiscriminately in search of it; they are bare-faced thieves with no organs adapted for carrying pollen; and as they go about in the most reckless fashion from one kind of plant to another, if they did ever by chance succeed in fertilizing a casual flower they would produce, not true species, but monstrous and meaningless hybrids. Therefore many plants protect themselves by endless devices against the crawling ants, just as obviously as they endeavor to allure the winged bees, beetles and butterflies. I may add that the head of strawberry clover is further protected against climbing insects by a number of lobed bracts at

its base which effectually disperse these thieving marauders.

While the strawberry clover is young and but recently opened, you might easily mistake it for a small and pinky section of Dutch clover. If you look closely, however, you will see that the petals are not so large, the tube not so deep, and the calyx much hairier. Nevertheless, the hairs do not seriously get in the way of the bee during the stage when the flowers are just fit for fertilization. As soon as the bee has left the plant, however, something happens which is quite different to the turning down of the florets in the Dutch clover. The calyx or little cup which encloses each separate flower begins to swell and inflate itself like a balloon or bladder. The whole flower head then becomes very compact and assumes a pink tint, so that it somewhat resembles a strawberry, whence its ordinary name, though, as a matter of fact, it is much more like a raspberry. The beautiful network on the bladder-like head is closely covered with numerous hairs, which further help to protect the pods from the attacks of insects.

The truth is, Dutch clover is a denizen of rich and lush meadows where it can take care of itself, and for which alone it is perfectly adapted. Strawberry clover, on the other hand, has chosen its home in close cropped pastures, where its creeping habit and low stature help to save it from destruction. The dry and hairy heads are not relished by sheep, and you will often see them left uncropped where the neighboring foliage has been closely nibbled. The swollen calyx with its hairs also keeps off egg-laying enemies.

Now, what is oddest of all, every one of twenty-five species of clover has some dodge of its own for protecting its seeds after fertilization. This shows how much these rich grains are sought after, and how carefully the plant is compelled to guard them. In some kinds, the calyx is a loose fluff of silky hair, enclosing the pod; in others it is hard like a nut, or has stiff and pointed lobes which are sharp and prickly. One species closes its hardened lips over the growing seeds and pre-

tends to be empty; a second develops a starry, thistle-like head, with tufts of thick hair which conceal the swelling pod from observation. But the subterranean clover has hit upon a still stranger and more ingenious device. It is a little creeping annual, much addicted to dry pastures or close-cropped hillsides, and particularly common on low knolls or barrows, nibbled over by numerous sheep and donkeys. Under these circumstances it has a hard fight to protect its nutritious seeds and seedlings. It has taken, therefore, to producing small heads of loose white flowers, which look at first sight like poor specimens of Dutch clover. But if you gaze closer you will see that each tiny head consists of two or three properly developed flowers, with four or five undeveloped or abortive blossoms in the center of the group. These undeveloped blossoms form a sort of living corkscrew. After fertilization the stems bend down toward the ground; the corkscrew-like abortive flowers worm their way by pushing into the sod; the pods are pressed down or buried in the loose mould; and the plant thus sows its own seed for itself quite as effectually as a gardener could sow it. This is, perhaps, the furthest point maternal solicitude has ever reached in the vegetable kingdom.

A PLANT THAT MELTS ICE.

BY

GRANT ALLEN.

IF you have ever visited the Alps in early spring, you will know well by sight the dainty little nodding bells of the Alpine soldanella,—twin flowers on one stalk, like fairy tocsins, which push their heads boldly through the ice of the névé, and form a border of blue blossoms on the edge of the snow sheet. As the snow melts upward the flowers open in zones, one after another, so that you can mark your ascent by the variations in flora and the different stages of development reached by the most persistent kinds at various levels.

By permission of Doubleday, Page & Co., from "Flashlights on Nature."

There is one adventurous little plant, however, among these competing kinds, which in its eagerness to make the most of the short Alpine summer does not even wait, like its neighbors, for the melting of the snow, but, vastly daring, begins to grow under the surface of the ice sheet, and melts a way up for itself by internal heat, like a vegetable furnace. It may fairly be called a slow combustion stove, not figuratively, but literally. It burns itself up in order to melt the ice above it. This wonderful plant is the Alpine soldanella, the hardiest and one of the prettiest of mountain flowers; it opens its fringed and pensile blue blossoms in the very midst of the snow, often showing its slender head above a thin layer of ice, where it fearlessly displays its two sister bells among the frozen sheet which still surrounds its stem in the most incredible fashion.

Comparatively few observers have noticed that the soldanella, fragile as it is, actually forces itself up through a solid coat of ice, not exactly by hewing its way, but by melting a path for itself in the crystal sheet above it. Yet such is really the case; it warms the ice as it goes. The buds begin to grow on the frozen soil before the ground is bare, under the hardened and compressed snow of the *névé*,—which at its edge is always ice-like in texture. They then bore their way up by internal heat (like that of an animal) through the delicate sheet that covers them; and they often expand their delicate blue or white blossoms, with the scalloped edges, in a cup-shaped hollow above, while a sheet of refrozen ice, through which they have warmed a tunnel or canal for themselves, still surrounds their stems and hides their roots and their flattened foliage. This is so strange a miracle of nature that it demands some explanation; the method by which the soldanella obtains its results is no less marvelous than the results themselves which it produces.

The winter leaves of the soldanella, which hibernate under the snow just as truly as the squirrel or the dormouse hibernates in its nest, are large, healthy, tough and evergreen. They are, in fact, just living reservoirs of

fuel (like the fat of the dormant bear), which the plant lays by during the heat of summer in order to burn it up again in spring for the use of its flowers. When I use this language, you will think at first I am speaking figuratively. But I am not; I mean it in just as literal a sense as when I say that the coal in the tender of a locomotive serves as fuel for the engine, or that the corn in the bin of a stable serves as fuel to heat the horse's body. These leaves contain material laid by for burning; and it is by burning that material up at the proper period that the soldanella manages to melt its way out of the wintry ice sheet, and so to steal a march upon competing species.

The process requires explanation, I admit; let us try to understand it. Everybody knows, as a matter of common experience, that animals are warmer in winter than the air which surrounds them, warm-blooded animals, that is to say, which form the only class that most people trouble about. Not everybody knows, however, that the same thing is more or less true of plants as well—that many plants have the power of evolving heat for themselves in considerable quantities. But this is actually true; indeed, all growing parts of a stem or young leaf-shoot must necessarily be slightly warmer than the air around them. All growing shoots combine with oxygen and therefore, rise in temperature. In early spring, when the ground just teems with sprouting seeds and swelling buds, with growing bulbs, or shooting tubers, the temperature of the soil is sensibly raised; and this very heat, evolved by germination, becomes itself in turn a cause of more germination; each seed and bulb and root and sucker helps to warm and start all the others. Spring largely depends upon the warmth thus produced. The earth, during this orgy of growth, is warmer by a good deal than the air about it; warmer even than it is in summer weather—indeed, were it not for the number of plants which thus start growing at once, growth would be almost impossible in very cold countries. Like roosting fowls, they warm one another.

At the risk of seeming tedious in this preliminary explanation, I must also add that flower buds and flower stems which grow and open very rapidly must similarly use up oxygen in their growth, and therefore rise in temperature. In a very few large and conspicuous flowers, such as the big white calla lily, this rise in temperature during the flowering period can be measured even with an ordinary thermometer. No bud can open without giving out heat; and the amount of heat is sometimes considerable.

And now, I hope, we are in a position to understand how soldanella acts, and why it does so. It has to eke out a livelihood in the mountain belt, just below the snow line; and it is a low-growing type, which must flower early or else it would soon be overshadowed by taller rivals. For growth is rapid in the Alps once the snow has melted. Soldanella has thus to blossom and to secure the aid of its insect fertilizers, at the precise moment when they emerge from their cocoons in the first warm days of the short Alpine summer. If it waited later it would be overtopped and obscured in a very few days by the dense and rapid growth of waving grasses, and aspiring globe-flowers, and long-stalked, bulbous plants that crowd all around it. So the soldanella seizes its one chance in life at the earliest possible moment, and makes haste to pierce its way through the solid ice sheet while lazier rivals passively await its melting. That alone has secured its survival and success in the crowded world of the Alpine pastures. For you must not forget that while to you and me the Alps are an unpeopled solitude, to the Alpine plants they are a veritable London of competing life-types.

The canny plant lays its plans deep, too, and begins well before hand. It has made preparations. All the previous summer it has been spreading its round leaves to the mountain sun, and laying by material for next year's flowering season. Leaves, you know, are the mouths and stomachs of plants; and the soldanella has a type of leaves admirably adapted to its peculiar purpose: expanded in the sunlight, they eat carbon and

hydrogen the livelong summer, and turn the combined oxygen loose upon the air under the influence of the sun. By the time winter comes, they are thick and leathery, filled with fuel for the spring, and, of course, evergreen. They have also long stalks which enable them during the summer to stretch up into the light, but in autumn they descend and flatten themselves against the soil, so as not to be crushed by the snows of winter.

The material laid by in the thickened leaves consists of starches, protoplasm, and other rich foodstuffs. The snow falls and the leaves, protected by their hard and leathery covering, remain unhurt by it. The food and fuel they have gathered is stored partly in the foliage and partly in the swollen underground root stock. All winter through, the plant is thus hidden under a compact blanket of snow, which becomes gradually hard and ice like by pressure. But as soon as the spring sun begins to melt the surface at the lower edge of the sheet, water trickles down through cracks in the ice and sets the root stock budding. The soldanella has collected its material deliberately as fuel, and uses it up on purpose to melt its passage. It absorbs oxygen from the air beneath the snow, combines it with the fuels in its own substance, evolves heat from their combination, and begins to send up nodding flower buds through the icy sheet that spreads above it.

The warmth the plant obtains by this curious process of slow, internal combustion, it first employs to melt a little round hole in the ice for its arched flower buds. At the beginning, the hollow which is formed above each pair of buds is hemispherical or dome shaped; the stem pushes its way up through a dome of air enclosed in the ice; and the water it liberates trickles down to the root, thus helping to supply moisture for further growth with its consequent heating. But by and by the stem lengthens and the bud is raised to a considerable height by its continuous growth. Still, so slight is the quantity of heat the poor little plant can evolve with all its efforts, that by the time the stem is an inch or two long, the lower part of the tunnel has curiously frozen over again.

In this stage, then, the melted space is no longer a dome; it assumes the form of a little balloon or round bubble of air, surrounding the flower bud. At the same time, the ice underneath, having frozen again, almost touches the stem, so that the bud seems to occupy a small clear area of its own in the midst of the sheet, with ice above, below, and all round it.

Gradually, in this way, the little buds manage to bore their way to the surface and to the sunshine on the outside of the ice sheet. At last the stalk melts its path out, and a flower appears on the top, in the center of a small, cup-shaped or saucer-shaped depression. The exquisite blue bells are thus seen blooming in profusion, apparently out of the ice itself, or as if stuck into it.

If you look at the foliage on the bare ground beneath you will find that, when the flowers open, the leaves are no longer thick and swollen. All the fuel they contained has by this time been burned up for warmth; all the formative material has been duly employed in making the buds or blossoms, with the stems that raised them; and nothing now remains but drained and flaccid skeletons from which every particle of living matter has been withdrawn and utilized. Later on new leaves are produced in turn from the root stock, after the ice has melted; and these new leaves, raising themselves on their long stalks, and catching the sunlight, begin afresh to accumulate material for next year's growth and next year's burning.

But why do the flowers want so much to reach the open air at all? Why should they not blossom contentedly under the enclosing ice sheet? Flowers, after all, are mere devices for the fertilization of the fruit; it is the seeds and the next generation that the plant itself is mainly thinking about. The plant wants its blossoms to attract the early spring bees and honey-sucking flies, which carry pollen from head to head, and so fertilize its seeds for it. And fertilization, to the practical minded plant, is the whole root of the question.

At the very same time that the soldanella raises its timid flowers, the bees and flies a little lower down the

mountain sides are just escaping from their cocoons as full fledged winged insects. It is for their sakes alone that the pensive blossoms tint themselves in blue or violet, for you will find throughout nature that blue is the true bee color; and flowers that depend most for fertilization on bees or their allies are almost always decked out in blue or purple.

Sometimes, however, the ice sheet above is too thick to pierce, and then the bud, after making manful efforts to melt its way out to the open air, is forced to give up the attempt in despair, and unfold its petals within its icy cavern. In that case, of course, no insect can visit it; and such cloistered blossoms are therefore obliged to have recourse to the inferior expedient of self-fertilization. I say inferior, because all higher plants strive as far as possible to produce seedlings which shall be the offspring of a distinct father and mother. It is in order to prevent such disastrous results on a large scale that the soldanella has invented its curious device for pushing its way boldly through its native ice sheet to the sky and the insects.

In the struggle for existence, every point of advantage any creature possesses must tell in its favor, and the soldanella has thus been enabled to hold its own bravely in the intermediate belt at the margin of the ice field. But its limits are narrow. In the open ground it is soon lived down by more hardy kinds, which rise higher into the air; its range is entirely bounded by a narrow belt just where the ice is melting. Above that point it cannot grow; below it taller enemies soon oust and dispossess it. It utilizes its short time between these two impossibilities.

Strange as it sounds, too, the ice itself acts as a sort of protective blanket or coverlet to the trustful soldanella. Only a plant that could pierce the ice could ever have hit upon such a paradoxical mode of warming itself by its own internal combustion. If an herb that flowers in the open were to make experiments in warming itself in the same manner, its attempt would necessarily fail, because as fast as it heated the air the wind would blow

the heated portion away, and the plant would therefore derive no benefit from its expenditure of fuel. But we all know how Eskimos can live in a snow hut, keeping it warm inside by their own breath and the heat of their bodies. It is just the same in principle with the soldanella's cave. The little dome or cavern gets warmed within by the respiration of the flower bud, and the heat thus produced is retained within the walls of the cavity. It is almost as though a mouse or other small animal were to try to bore a path for itself through an ice barrier, not by gnawing the ice, but by breathing upon it slowly till it melted.

See, then, how absolutely the soldanella behaves like a man who is making a conservatory. It lays by fuel for the stove in its leaves to keep its flower buds warm and to force them in spring at a time when they could not blossom without the artificial heat thus supplied them. It keeps in this heat within a transparent covering, the doors of which are never opened. As for light, that reaches it through the crystal summit. But it employs the heat also to bore its way out; and, as its ultimate object is to get its young seeds fertilized, it finally pushes its flowers out into the open air, where they may receive the attentions of the fertilizing insects,—just as the gardener does, without knowing why, when he wishes seed set. The pendent, bell-shaped blossoms again, even after they are open, are admirably adapted for keeping in the heat; and they are also exactly fitted to the shape and size of the bees and flies that act as their chartered carriers of pollen. A plant, in short, has to accommodate itself at every point to the needs of its situation; it has to secure for itself a firm foothold in the soil, and a due share of food from the surrounding air (for its diet after all is chiefly gaseous); it has to take care that its pollen shall be duly dispersed, and its seedlets fertilized; and finally, it has to see that its young are satisfactorily settled in the world, and deposited on likely spots where they can germinate to advantage. It must be a good parent as well as a prudent and cautious adventurer.

The struggle for life carried on under these circumstances has sharpened the wits of plants to a far higher degree than most people imagine. Plants have developed almost as many dodges and devices for securing food or avoiding enemies as animals themselves have; and this single instance enables us to see with what forethought and cleverness they often provide against adverse chances. *Soldanella*, indeed, could not exist at all upon its ice-clad heights if it did not lay up food and fuel in summer against the needs of winter, like the bee and the ant; if it did not burn up its own fat for warmth like the dormouse; if it did not tunnel the ice as the mole tunnels the earth; if it did not retire beneath the snow sheet on the approach of winter as the queen wasp retires into the shelter of the moss when frosts begin to kill her worker sisters, or as the squirrel retires into his hole in a tree at the approach of December. Ancestral instinct teaches the one just as much as it teaches the other; and those who have closest watched the habits and manners of plants have the highest respect for their industry and intelligence.

Looked at from this point of view, we may consider indeed that every seed, bulb, or tuber, is not merely a reservoir of material for future growth, but also a reservoir of fuel for supplying the heat necessary to the first stages of sprouting or germination. And without elaborating this question further, I may add that if you will examine closely many early spring buds and flowers, especially such as willow and hazel catkins, you will find not only that they are formed over winter and enclosed in warm overcoats to protect them from the cold, but also that they grow in spring before the air is warm enough to stimulate growth directly,—or in other words, that they depend in part for heat upon the consumption of their own internal fuels.

RECORDS OF PLANTS AND ANIMALS.

BY

SIR ARCHIBALD GEIKIE, F. R. S.

BROADLY considered, there are two distinct ways in which Plants and Animals leave their mark upon the surface of the earth. In the first place, they act directly by promoting or arresting the decay of the land, and by forming out of their own remains deposits which are sometimes thick and extensive. In the second place, their remains are transported and entombed in sedimentary accumulations of many different kinds, and furnish important evidence as to the conditions under which these accumulations were formed. Each of these two forms of memorial deserves the most generally interesting departments of geology, and those in which the history of the earth is principally discussed.

I. *Direct Action of Living Things upon the Surface of the Globe.*—This action is often of a destructive kind, both plants and animals taking their part in promoting the general disintegration of rocks and soils. Thus, by their decay they furnish to the soil those organic acids which have been referred to as so important in increasing the solvent power of water, and thereby promoting the waste of rocks. By thrusting their roots into crevices of cliffs, plants loosen and gradually wedge off pieces of rock, and by sending their roots and rootlets through the soil, they open up the subsoil to be attacked by the air and the descending moisture. The action of the common earth-worm in bringing up fine soil to be exposed to the influences of wind and rain has an enormous effect. Many burrowing animals also, such as the mole and rabbit, throw up large quantities of soil and subsoil which are liable to be blown or washed away.

On the other hand, the action may be conservative, as, for instance, where, by forming a covering of turf, vegetation protects the soil underneath from being rapidly removed, or where sand-loving plants bind together the

From "Geology." By Sir Archibald Geikie.

surface of dunes, and thereby arrest the progress of the sand, or where forests shield a mountainside from the effects of heavy rains and descending avalanches.

(1) *Deposits Formed of the Remains of Plants.*—But it is chiefly by the aggregation of their own remains into more or less extensive deposits that plants and animals leave their most prominent and enduring memorials. As examples of the way in which this is done by plants, reference may be made to peat-bogs, mangrove-swamps, infusorial earth, and calcareous sea-weeds.

Peat-bogs.—In temperate and arctic countries, marshy vegetation accumulates in peat-bogs over areas from an acre or two to many square miles, and to a depth of sometimes fifty feet. These deposits are largely due to the growth of bog-mosses and other aquatic plants which, dying in their lower parts, continue to grow upward on the same spot. On flat or gently-inclined moors, in hollows between hills, on valley-bottoms, and in shallow lakes, this marshy vegetation accumulates as a wet spongy fibrous mass, the lower portions of which by degrees become a more or less compact dark-brown or black pulpy substance, wherein the fibrous texture, so well seen in the upper or younger parts, in large measure disappears. In a thick bed of peat, it is not infrequently possible to detect a succession of plant remains, showing that one kind of vegetation has given place to another during the accumulation of the mass. In Europe, as has been already mentioned, peat-bogs often rest directly upon fresh-water marl containing remains of lacustrine shells. In every such case, it is evident that the peat has accumulated on the site of a shallow lake which has been filled up, and converted into a morass by the growth of marsh-plants along its edges and over its floor. The lowest parts of the peat may contain remains of the reeds, sedges, and other aquatic plants which choked up the lake. Higher up, the peat consists almost entirely of the matted fibres of different mosses, especially of the kind known as Bog-moss or Sphagnum. The uppermost layers may be full of roots of different heaths which spread over the surface of the bog.

The rate of growth of peat has been observed in different situations in Central Europe to vary from less than a foot to about two feet in ten years; but in more northern latitudes the growth is probably slower. Many thousand square miles of Europe and North America are covered with peat-bogs, those of Ireland being computed to occupy a seventh part of the surface of the island, or upwards of 4,000 square miles.

As the aquatic plants grow from the sides toward the centre of a shallow lake, they gradually cover over the surface of the water with a spongy layer of matted vegetation. Animals, and man himself, venturing on this treacherous surface sink through it, and may be drowned in the black peaty mire underneath. Long afterwards, when the morass has become firm ground, and openings are made in it for digging out the peat to be used as fuel, their bodies may be found in an excellent state of preservation. The peaty water so protects them from decay that the very skin and hair sometimes remain. In Ireland, numerous skeletons of the great Irish elk have been obtained from the bogs, though the animal itself has been extinct since before the beginning of the authentic history of the country.

Mangrove-swamps.—Along the flat shores of tropical lands, the mangrove trees grow out into the salt water, forming a belt of jungle which runs up or completely fills the creeks and bays. So dense is the vegetation that the sand and mud, washed into the sea from the land, are arrested among the roots and radicles of the trees, and thus the sea is gradually replaced by firm ground. The coast of Florida is fringed with such mangrove-swamps for a breadth of from five to twenty miles. In such regions, not only does the growth of these swamps add to the breadth of the land, but the sea is barred back, and prevented from attacking the newly-formed ground inside.

Infusorial Earth.—A third kind of vegetable deposit to be referred to here is that known by the names of infusorial earth; diatom-earth, and tripoli-powder. It consists almost entirely of the minute frustules of micro-

scopic plants called diatoms, which are found abundantly in lakes and likewise in some regions of the ocean. These lowly organisms are remarkable for secreting silica in their structure. As they die, their singularly durable siliceous remains fall like a fine dust on the bottom of the water, and accumulate there as a pale gray or straw-colored deposit, which, when dry, is like flour, and in its pure varieties is made almost entirely of silica (90 to 97 per cent.). Underneath the peat-bogs of Britain a layer of this material is sometimes met with. One of the most famous examples is that of Richmond, Virginia, where a bed of it occurs thirty feet thick. At Bilin, in Bohemia, also, an important bed has long been known. The bottom of some parts of the Southern Ocean is covered with a diatom ooze made up mainly of siliceous diatoms, but containing also other siliceous organisms (radiolarians) and calcareous foraminifera.

Accumulations of Sea-weeds.—Yet one further illustration of plant-action in the building up of solid rock may be given. As a rule the plants of the sea form no permanent accumulations, though here and there under favorable conditions, such as in bays and estuaries, they may be thrown up and buried under sand so as eventually to be compressed into a kind of peat. Some sea-weeds, however, abstract from sea-water carbonate of lime, which they secrete to such an extent as to form a hard stony structure, as in the case of the common nullipore. When the plants die, their remains are thrown ashore and pounded up by the waves, and being durable they form a white calcareous sand. By the action of the wind, this sand is blown inland and may accumulate into dunes. But unlike ordinary sand, it is liable to be slightly dissolved by rain-water, and as the portion so dissolved is soon re-deposited by the evaporation of the moisture, the little sand-grains are cemented together, and a hard crust is formed which protects the sand underneath from being blown away. Meanwhile rain-water percolating through the mounds gradually solidifies them by cementing the particles of sand to each other, and thick masses of solid white stone are thus produced. Changes of this kind

have taken place on a great scale at Bermuda, where all the dry land consists of limestone formed of compacted calcareous sand, mainly the detritus of sea-weeds.

(2) *Deposits Formed of the Remains of Animals.*—Animals are, on the whole, far more successful than plants in leaving enduring memorials of their life and work. They secrete hard outer shells and internal skeletons endowed with great durability, and capable of being piled up into thick and extensive deposits which may be solidified into compact and enduring stone. On land, we have an example of this kind of accumulation in the lacustrine marl already described as formed of the congregated remains of various shells. But it is in the sea that animals, secreting carbonate of lime, build up thick masses of rock, such as shell-banks, ooze, and coral reefs.

Shell-banks.—Some molluscs, such as the oyster, live in populous communities upon submarine banks. In the course of generations, thick accumulations of their shells are formed on these banks. By the action of currents also large quantities of broken shells are drifted to various parts of the sea-bottom not far from land. Such deposits of shells, *in situ* or transported, may be more or less mixed with or buried under sand and silt, according as the currents vary in direction and force. On the other hand, they may be gradually cemented into a solid calcareous mass, as has been observed off the coast of Florida, when they form on the sea-bottom a sheet of limestone, made up of their remains.

Ooze.—From observations made during the great expedition of the Challenger, it has been estimated that in a square mile of the tropical ocean down to a depth of 100 fathoms there are more than 16 tons of carbonate of lime in the form of living animals. A continual rain of dead calcareous organisms is falling to the bottom, where their remains accumulate as a soft chalky ooze. Wide tracks of the ocean-floor are covered with a pale-gray ooze of this nature, composed mainly of the remains of the shells of the foraminifer *Globigerina*. In the north Atlantic this deposit probably extends not less than 1,300 miles

from east to west, and several hundred miles from north to south.

Here and there, especially among volcanic islands, portions of the sea-bed have been raised up into land, and masses of modern limestone have thereby been exposed to view. Though they are full of the same kind of shells as are still living in the neighboring sea, they have been cemented into compact and even somewhat crystalline rock, which has been eaten into caverns by percolating water, like limestones of much older date. This cementation, as above remarked, is due to water permeating the stone, dissolving from its outer parts the calcareous matter of shells, corallines, and other organic remains, and re-depositing it again lower down, so as to cement the organic detritus into a compact stone.

Coral-reefs offer an impressive example of how extensive masses of solid rock may be built up entirely of the aggregated remains of animals. In some of the warmer seas of the globe, and notably in the track of the great ocean-currents, where marine life is so abundant, various kinds of coral take root upon the edges and summits of submerged ridges and peaks, as well as on the shelving sea-bottom facing continents or encircling islands. These creatures do not appear to flourish at a greater depth than 15 or 20 fathoms, and they are killed by exposure to sun and air. The vertical space within which they live may therefore be stated broadly as about 100 feet. They grow in colonies, each composed of many individuals, but all united into one mass, which at first may be merely a little solitary clump on the sea-floor, but which, as it grows, joins other similar clumps to form what is known as a reef.

Each individual secretes from the sea-water a hard calcareous skeleton inside its transparent jelly-like body, and when it dies, this skeleton forms part of the platform upon which the next generation starts. Thus the reef is gradually built upward as a mass of calcareous rock, though only its upper surface is covered with living corals. These creatures continue to work upward until they reach low-water mark, and then their further up-

ward progress is checked. But they are still able to grow outward. On the outer edges of the reef they flourish most vigorously, for there, amid the play of the breakers, they find the food that is brought to them by the ocean-currents. From time to time fragments are torn off by breakers from the reef and roll down its steep front. There, partly by the chemical action of the sea-water, and partly by the fine calcareous mud and sand, produced by the grinding action of the waves and washed into their crevices, these loose blocks are cemented into a firm, steep slope, on the top of which the reef continues to grow outwards. Blocks of coral and quantities of coral-sand are also thrown up on the surface of the reef, where by degrees they form a belt of low land above the reach of the waves. On the inside of the reef, where the corals cannot find the abundant food-supply afforded by the open water outside, they dwindle and die. Thus the tendency of all reefs must be to grow seawards, and to increase in breadth. Perhaps their breadth may afford some indication of their relative age.

Where a reef has started on a shelving sea-bottom near the coast of a continent, or round a volcanic island, the space of water inside is termed the Lagoon Channel. Where the reef has been built up on some submarine ridge or peak, and there is consequently no land inside, the enclosed space of water is called a Lagoon, and the circular reef of coral is known as an Atoll. If no subsidence of the sea-bottom takes place, the maximum thickness of a reef must be limited by the space within which the corals can thrive—that is, a vertical depth of about 100 feet from the surface of the sea. But the effect of the destruction of the ocean-front of the reef, and the piling up of a slope of its fragments on the sea-bottom outside, will be to furnish a platform of the same materials on which the reef itself may grow outward, so that the united mass of calcareous rock may attain a very much greater thickness than 100 feet. On the other hand, if the sea-bottom were to sink at so slow a rate that the reef-building corals could keep pace with the subsidence, a mass of calcareous rock many thousand feet thick might

obviously be formed by them. It is a disputed question in which of these two ways atolls have been formed.

It is remarkable how rapidly and completely the structure of the coral-skeleton is effaced from the coral-rock, and a more or less crystalline and compact texture is put in its place. The change is brought about partly by the action of both sea-water and rain-water in dissolving and re-depositing carbonate of lime among the minute interstices of the rock, and partly also by the abundant mud and sand produced by the pounding action of the breakers on the reef, and washed into the crevices. On the portion of a reef laid dry at low water, the coral-rock looks in many places as solid and old as some of the ancient white limestones and marbles of the land. There, in pools where a current or ripple of water keeps the grains of coral-sand in motion, each grain may be seen to have taken a spherical form unlike that of the ordinary irregularly rounded or angular particles. This arises because carbonate of lime in solution in the water is deposited round each grain as it moves along. A mass of such grains aggregated together is called oölite, from its resemblance to fish-roe. In many limestones, now forming wide tracts of richly cultivated country, this oölitic structure is strikingly exhibited. There can be no doubt that in these cases it was produced in a similar way to that now in progress on coral-reefs.

In the coral tracts of the Pacific Ocean there are nearly 300 coral islands, besides extensive reefs round volcanic islands. Others occur in the Indian Ocean. Coral-reefs abound in the West Indian Seas, where, on many of the islands, they have been upraised into dry land, in Cuba to a height of 1,100 feet above sea-level. The Great Barrier Reef that fronts the northeastern coast of Australia is 1,250 miles long, and from 10 to 90 miles broad.

There are other ways in which the aggregation of animal remains forms more or less extensive and durable rocks. To some of these reference will be made in later chapters. Enough has been said here to show that by the accumulation of their hard parts animals leave per-

manent records of their presence both on land and in the sea.

II. *Presentation of Remains of Plants and Animals in Sedimentary Deposits.*—But it is not only in rocks formed out of their remains that living things leave their enduring records. These remains may be preserved in almost every kind of deposit, under the most wonderful variety of conditions. And as it is in large measure from their occurrence in such deposits that the geologist derives the evidence that successive tribes of plants and animals have peopled the globe, and that the climate and geography of the earth have greatly varied at different periods, we shall find it useful to observe the different ways in which the remains both of plants and animals are at this moment being entombed and preserved upon the land and in the sea. With the knowledge thus gained, it will be easier to understand the lessons taught by the organic remains that lie among the various solid rocks around us.

It is evident that in the vast majority of cases, the plants and animals of the land leave no perceptible trace of their presence. Of the forests that once covered so much of Central and Northern Europe, which is now bare ground, most have disappeared, and unless authentic history told that they had once flourished, we should never have known anything about them. There were also herds of wild oxen, bears, wolves, and other denizens contemporaneous with the vanished forests. But they too have passed away, and we might ransack the soil in vain for any trace of them.

If the remains of terrestrial vegetation and animals are anywhere preserved it must obviously be only locally, but the favorable circumstances for their preservation, although not everywhere to be found, do present themselves in many places if we seek for them. The fundamental condition is that the relics should, as soon as possible after death, be so covered up as to be protected from the air and from too rapid decomposition. Where this condition is fulfilled, the more durable of them may be preserved for an indefinite series of ages.

(a) On the Land there are various places where the remains both of plants and animals are buried and shielded from decay. To some of these reference has already been made. Thus amid the fine silt, mud, and marl gathering on the floors of lakes, leaves, fruits, and branches, or tree-trunks, washed from the neighboring shores, may be imbedded, together with insects, birds, fishes, lizards, frogs, field-mice, rabbits, and other inhabitants. These remains may of course often decay on the lake-bottom, but where they sink into or are quickly covered up by the sediment, they may be effectually preserved from obliteration. They undergo a change, indeed, being gradually turned into stone. But this conversion may be effected so gently as to retain the finest microscopic textures of the original organisms.

In peat-bogs also, as stated elsewhere, wild animals are often engulfed, and their soft parts occasionally preserved as well as their skeletons. The deltas of river-mouths must receive abundantly the remains of animals swept off by floods. As the carcasses float seawards, they begin to fall to pieces and the separate bones sink to the bottom, where they are soon buried in the silt. Among the first bones to separate from the rest of the skeleton are the lower jaws. We should therefore expect that in excavations made in a delta these bones would occur most frequently. The rest of the skeleton is apt to be carried farther out to sea before it can find its way to the bottom. The stalagmite floor of caverns is an admirable material for enclosing and preserving organic remains. The animals that fell into these recesses, or used them as dens in which they lived or into which they dragged their prey, have left their bones on the floors, where encased in or covered by solid stalagmite, these relics have remained for ages. Most of our knowledge of the animals which inhabited Europe at the time when man appeared, is derived from the materials disinterred from these Bone-caves. We may also refer here to the travertine formed by mineral-springs and to the facility with which leaves, shells, insects, and small birds, reptiles, or mammals may be enclosed and preserved in

travertine. Thus, while the plants and animals of the land for the most part die and decay into mere mould, there are here and there localities where their remains are covered up from decay and preserved as memorials of the life of the time.

(b) On the bottom of the Sea the conditions for the preservation of organic remains are more general and favorable than on land. Among the sands and gravels of the shore, some of the stronger shells that live in the shallower waters near land may be covered up and preserved, though often only in rolled fragments. It is below tide-mark, however, and more especially beneath the limit to which the disturbing action of breakers descends, that the remains of the denizens of the sea are most likely to be buried in sediment and to be preserved there as memorials of the life of the sea. It is evident that hard and therefore durable relics have the best chance of escaping destruction. Shells, corals, corallines, spicules of sponges, teeth, vertebræ, and ear-bones of fishes may be securely entombed in successive layers of silt or mud. But the vast crowds of marine creatures that have no hard parts must always perish without leaving any trace whatever of their existence. And even in the case of those which possess hard shells or skeletons, it will be easily understood that the great majority of them must be decomposed upon the sea-bottom, their component elements passing back again into the sea-water from which they were originally derived. It is only where sediment is deposited fast enough to cover them up and protect them before they have time to decay, that they may be expected to be preserved.

In the most favorable circumstances, therefore, only a very small proportion of the creatures living in the sea at any time leave a tangible record of their presence in the deposits of the sea-bottom. It is in the upper waters of the ocean, and especially in the neighborhood of land, that life is most abundant. The same region also is that in which the sediment derived from the waste of the land is chiefly distributed. Hence it is in these marginal parts of the ocean that the conditions for preserving memo-

rials of the animals that inhabit the sea are best developed.

As we recede from the land, the rate of deposit of sediment on the sea-floor gradually diminishes, until in the central abysses it reaches that feeble stage so strikingly brought before us by the evidence of the manganese nodules. The larger and thinner calcareous organisms are attacked by the sea-water and dissolved, apparently before they can sink to the bottom; at least their remains are comparatively rarely found there. It is such indestructible objects as sharks' teeth and vertebræ and ear-bones of whales that form the most conspicuous organic relics in these abysmal deposits.

Summary.—Plants and animals leave their records in geological history, partly by forming distinct accumulations of their remains, partly by contributing their remains to be imbedded in different kinds of deposits both on land and in the sea. As examples of the first mode of chronicling their existence, we may take the growth of marsh-plants in peat-bogs, the spread of mangrove-swamps along tropical shores, and the deposition of infusorial earth on the bottom of lakes and of the sea; the accumulation of nullipore sand into solid stone, the formation of extensive shell-banks in many seas, the wide diffusion of organic ooze over the floor of the sea, and the growth of coral reefs. As illustrations of the second method, we may cite the manner in which the remains of terrestrial plants and animals are preserved in peat-bogs, in the deltas of rivers, in the stalagmite of caverns, and in the travertine of springs; and in the way in which the hard parts of marine creatures are entombed in the sediments of the sea-floor, more especially along that belt fringing the continents and islands, where the chief deposit of sediment from the disintegration of the land takes place. Nevertheless, alike on land and sea, the proportion of organic remains thus sealed up and preserved is probably always but an insignificant part of the total population of plants and animals living at any given moment.

BEGINNINGS OF PLANT LIFE.

BY

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ALTHOUGH the origin of life is practically a sealed book to us, the processes of life are fairly well understood. Living organisms may be roughly classified as plants and animals. Plants are storers of the sun's energy, and animals reconvert this stored energy into other forms. The plant is thus a fuel former, and the animal a heat engine. Let us consider the matter in detail. Of the flow of radiant energy that is for ever being poured out in such apparently wasteful profusion from the surface of the sun, a minute portion falls upon the earth and warms it. When it falls upon a growing leaf, it does wonderful work. It breaks the bonds that weld together the molecules of combined carbon and oxygen. The welding force is ten times as strong as the most tensile steel, yet, in these wonderful leaf laboratories solar energy sets the atoms vibrating and tears them asunder, liberating the oxygen into the atmosphere. Then, without permitting the welding force to act, chlorophyll—the green pigment—helps the living matter, in some way not as yet understood, to build the dissevered and other atoms into complex groups. In these the atoms wait, as it were, with folded arms, ready when the time comes to again seize upon their partners, and, as free gaseous molecules, to resume their dance in the sunlight.

The ways in which plants and animals obtain and utilize their food are sometimes very complex indeed, and sometimes very simple. One of the single-celled organisms—the amoeba—comes into contact with something it can digest; slowly the substance is engulfed or enfolded; then, when all the nutritive material has been utilized, the living cell rejects the useless remainder. Almost as

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simply the green particle floating in water absorbs its necessary salts, absorbs its carbonic acid, in the sunlight liberates oxygen, and builds up the complex out of the simple, just as the giant tree in the forest does. The sharp line that, with complex organisms, divides the animal from the vegetable, loses distinctness as we descend in the scale of complexity, until it becomes hard to tell which is animal and which is vegetable. Even the fact that green plants are able to utilize carbonic acid as a source of carbon-supplies, does not always help us, for there are animals with chlorophyll, and there are plants, like mushrooms, which are not green. Many an animal remains fixed in its habitat, especially during one stage of its existence; many simple plants, such as *Volvox globator*, spin and travel in the water as full of apparent animal vitality as almost any animal. But it is only with the lowly organisms that this fusion of characteristics occur; the contrast is marked enough higher up. The plant is characteristically a reducing agent, the animal is as characteristically an oxidizer; the plant stores potential energy, the animal converts this energy into heat and motion; the plant absorbs carbonic acid, decomposes it, and liberates oxygen; the animal uses the liberated oxygen and recombines it with carbon, and this burning develops heat and gives the power of the animal just as truly as the combustion of the fuel of an engine develops heat which is partly converted into mechanical work.

When we burn a heap of plant rubbish it almost disappears—as gases—into the atmosphere, leaving a mass of light-colored ashes. All that has burned away the plant may again get from the air, but the salts that form the ash constituents it must get from water in the soil. To do this it sends out roots with delicate root-hairs near their growing-points, and, by a peculiar action, these hairs absorb the saline water. From the roots the salt-laden water passes up the stem of the plant into the leaves, and thus reaches the place where the chlorophyll is spread out in thin layers, and exposed to the action of sunlight. As we go far back in time we seem to see Nature making

apprentice efforts—spreading the chlorophyll as a covering to vegetable masses. Gradually more and more perfect methods were acquired, the chlorophyll surface became thinner and thinner, then—to produce contact with much air, so as to get at much carbonic acid—the parallel-veined plants (or Monocotyledons) divided their leaves into thinner and thinner pennants to wave in the sunshine. But Nature, becoming more and more economical of material, began to reticulate the sap-bearing tubes into the complex net of the Dicotyledons; then placed the leaf on a thin stem, the petiole, so that the bannerets might flutter as freely in the air as the long streaming pennants of the grasses and palms. With many minor families, flowering plants may be grouped, broadly, as net-veined and parallel-veined. These differ in the number of their seed-leaves (Monocotyledons, with one; Dicotyledons, with two), in the structure and growth of their stems, and in many other ways. The early vegetation of the earth was flowerless, and for a long time there were no insects—two facts that must be taken together, since we know that in the majority of our flowering plants the insects carry from blossom to blossom the fertilizing golden dust or pollen which converts possible seeds into real seeds. In earlier days, the plants had not “unfurled their colored flags, to lure winged creatures to their nectar stores.”

And now let us consider the function of the flower. To make the beginning of a new life—whether of plant or of animal—it is required, save with very lowly creatures, and in exceptional cases, for instance when buds are set free, that there be a union of two elements of different kinds; a sperm-cell or male element, and an egg-cell or female element. Failing union, both die. The male elements of flowering plants are contained in the pollen-dust formed in the stamens of the flower; the female elements or egg-cells lie within the ovules or possible seeds inside the seed-box or ovary, in the central parts of the flower, which are called carpels. Now, it is better for evolution that these male and female elements should come from different organisms. Hence, in pine trees the cones bearing the egg-cells are at the tips of the branches, while

everywhere throughout the tree cluster the pollen-bearing growths; and so numerous are the pollen grains, that, in the season, when some conifers are struck, the mass of golden dust is wafted by the wind like a cloud of solid sunshine from the tree; so abundant is it that the very ground grows yellow where it falls. Among the many wind-driven wanderers some find egg-cells, and the possible seeds or ovules turn into real seed, that is, a young life or embryo develops within. But in the flowering plants this carrying of the fertilizing dust is in most cases the work of insects, who, working for their own ends, serve that of plant multiplication at the same time. Many naturalists believe that all the beauty of form, all the brilliancy of coloring, all the wonders of perfume, and the sweetness of nectars, have been evolved to attract insects, so that the male and female cells of different blossoms of the same kind may be brought together, and loveliness and perfection result from the variation in the offspring, due to cross fertilization.

We may look upon a flowering tree as the highest development of vegetation. It consists of root, stem, branches, and leaves; at a certain season some incipient leaves are modified and become flowers, and parts of these flowers—the stamens and carpels—produce the pollen dust and the ovules, within which, as we have said, there are the male elements and the female elements. The roots hold the tree in its place and supply it with water and salts; the stem is a means of communication, and uplifts the leaves in the air; the leaves use the energy or power of the sunlight to convert the raw materials furnished by water, earth, and air into complex stuffs which go to build up living matter. Part of the manufactured sap of the leaves is carried back to the roots for their nourishment, part goes to thicken the branches and stem, and part supplies the flowers and fruit.

The flower is the organ of reproduction. When perfect, it consists of four whorls of modified leaves. The first whorl is the calyx or cup. It consists of protecting, steadying leaves or sepals, generally green, but sometimes colored, as in the Fuchsia and in the singular

Bougainvillea. The next whorl is the corolla, and it is usually to this that the flower owes its beauty. Its parts—called petals—have the function of attracting insects, and they often protect the more essential parts within from rain and wind, and from unwelcome visitors. The next whorl consists of stamens; rod-like leaves which bear on their tips the anthers, often hanging delicately poised on light filaments. Within the anthers is formed the fertilizing dust or pollen which contains the male elements. The central organ, the pistil, has at its base the seed-box or ovary, containing the ovules, each of which again contains an egg-cell or ovum. At its tip is a sticky body called the stigma. When a pollen grain falls upon this adhesive surface it is caught, and it begins to send out a filament that grows and travels through the style—which connects the stigma with the ovary, or seed-box—till it reaches an ovule, which it enters by a small opening. When the male element from the pollen tube unites with the female element or egg-cell within the ovule, the new life begins; the ovule has become a real seed, it contains a young life from which a plant similar to the parent may grow, again to repeat the process. That cross fertilization may take place, an insect visits the flower, attracted by the perfume or the color, which indicates that a certain nectar is hidden there. While attempting to sip the sweet juice the insect comes into contact with the pollen, and the little visitor carries this pollen to the pistil of the next flower which it investigates; thus the male elements of one flower fertilize the egg-cells of another. It is interesting to note that many insects, like bees, keep for a time to one kind of flower, for, of course, the pollen of the wild thyme would be of no use if landed on the stigma of the broom.

In flowerless plants, which usually live in water or in damp places, the male elements are actively moving bodies like those of almost all animals, able to seek out for themselves—and in some cases to find—the egg-cells of their kind. This is so in club-mosses, ferns, horse-tails, mosses, liverworts, and in many seaweeds and fungi. In the strange flowering plants called Cycads,

such as the Maiden Hair Tree, similar actively moving male elements come out of the pollen-tube, and make for the egg-cells, thus removing one of the most notable differences between flowerless and flowering plants.

Most complex, most wonderful, are the ways in which the structure of flowers and the structure of insects are suited to one another. They fit like hand and glove. They present us with miracles of adaptation, especially in the case of some rare orchids, and the rare insects that visit them. But not alone is the flower surprising. Everywhere there is the extraordinary, unconscious ingenuity, if we may say so, by which plants compete with one another, vying with each other in their efforts to absorb the sunlight, to procure the soil-water, to mature and scatter their seeds, having stored therein nutrient material for the early stage of their germination; then, by prodigal production of such seeds, to secure a chance that every available spot shall be the bed for the germination, growth, and perfection of similar progeny. Yet, though plants present such profusion of wonder, they are far outdone by the organisms it is their duty to provide food for. When we come to consider the perfection of skill, the surprising mental qualities, and the marvellous emotions of the higher animals, we are confronted by facts, each one a miracle. As Walt Whitman said, the mouse can out-stagger sextillions of infidels.

SOME WONDERS OF PLANT LIFE.

BY

RICHARD KERR, F. G. S., F. R. A. S., ETC.

THE MONKEY'S DINNER-BELL.

WE are accustomed to noisy outbursts when we are in the neighborhood of certain juvenile representatives of the animal kingdom. Such outbursts we attribute to "animal spirits"—and, unfortunately, we know too frequently many noisy results to

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proceed from the use of "vegetable spirits," or spirits extracted from certain plants; but we are wholly unprepared for noisy and obstreperous conduct on the part of the plants themselves.

Trees and their allies behave themselves in a becoming manner. To us they are models of steady, decorous conduct.

This exemplary behavior, which is the general rule at home, leads one to the deceptive idea that the trees of other parts of the world are endowed with the same self-respect. But this is far from being the case.

Certain trees of the West Indies and of the tropical parts of South America instead of being circumspect, at certain seasons of the year seem to revel in playing pranks not only upon the natives, but also upon the monkeys that honor them with denizenship.

When trees are given to frivolity an allowance must be made for the comic antics of the monkeys of the New World.

It will be seen from the following that some idea of the natural laws prevailing among certain species of trees in the west may be obtained without journeying across the Atlantic.

A few winters ago a gentleman received a consignment of vegetable curiosities from a relative in British Guiana. Among the number was a sand-box nut, botanically known as *Hura crepitans*.

Not a word was said about the proclivities of these nuts. Perhaps it was just as well. It may have been better for his education that he was left in ignorance. The nut itself would educate him. But education ought to be a gradual process. If the nuts thought at all, they thought otherwise.

This beautiful nut specimen, with fourteen compartments comprising its periphery, and with radiations forming an excellent design in geometry, was placed under a glass shade on the mantelpiece. It was frequently taken out, handled, admired, and its fourteen kernels rattled. It was then replaced side by side with other ornaments.

The owner was proud of his possession, for no one else in the town had one. The museum authorities could not boast of a single specimen.

I commend the curator for his respect for his glass cases, and for his care of the eyes of his clients.

For several months the nut was in high favor and was prized beyond most of the specimens in the collection of curios. There was no need, however, to prize it, for it had a peculiar way of prizing itself.

It was a harmless custom of the possessor to go round each night to fasten the windows and doors, and to see that everything was safe.

One night, while he was thus occupied, without any warning whatever, a loud report, quite up to that of any pistol, startled the whole house. He naturally thought he had been fired at through the window, and this surmise gained support owing to the shower of broken glass that followed the report.

The window was not broken, but the glass case was gone from the mantelpiece, and alas! the beautiful sand-box nut was gone as well.

He found the fourteen kernels and the various pieces that made up the lovely device, but "not all the king's horses, nor all the king's men" could build up the box-nut as it was, again.

At first the owner was sorry for his loss, but he had gained information. The experience opened up in a moment the why and the wherefore of this startling explosion.

He could get more box-nuts from Guiana, and he resolved to take good care to prevent their apparent suicide.

It appears that the explosion is necessary for the protection of the trees.

Owing to this effort the kernels are scattered several yards away, and do not fall immediately under the trees, as would be the case if the pods opened gradually.

It requires no great stretch of imagination to see that if the seeds fell under the tree they would take root in the decayed tropical vegetation, would grow up, and

would ultimately impoverish the parent tree. This, in time, would tend to the degeneracy of the species.

A general, who has spent several years in Jamaica, informs me that one of these trees, growing immediately in front of his quarters, was the source of some lively scenes during the ripening season.

Repeatedly were the fragments of the exploded nuts sent in through the windows.

The monkeys in the branches of *Hura crepitans* never seem to become reconciled to these explosions, for as soon as a report takes place they scamper away to the other side of the tree, only to be met with more reports and consequent terror. For this reason the nuts are called "The Monkey's Dinner-Bell."

If these trees could be influenced to grow here it might be an advantage to the farmers. One or two trees in a field would produce sufficient nuts to act as scarecrows.

It is worth notice that under favorable conditions all the compartments of each nut explode simultaneously. This arises from the equal drying up and contraction of the layers of the cell walls.

Sometimes the fragments and kernels are scattered to a distance of fifteen or sixteen yards away from the outermost limits of the tree.

In the largest of the museums in Kew Gardens the curator is well aware of the love of liberty inherent in the box-nut. One bottleful of specimens is preserved in a solution, thus preventing the drying and contracting process. Close by is a glass jar containing dried specimens. These can scarcely burst asunder, because several strands of stout copper wire have been passed around the circumference, and several times across the nut.

We can form some idea of the pent-up force in each little nut when we see them bound with copper wire sufficiently strong to bind a man to a post.

With patience and care it is possible to remove all the kernels and to fill in all the cavities with lead. In this form they are used as paper weights.

Hura crepitans is a branching tree that attains to a height of forty feet. It is often planted in the neighbor-

hood of houses, notwithstanding its surprising powers. This is owing to the abundance of its glossy, poplar-like leaves, which afford a splendid protection from the rays of a tropical sun.

Some of the violets explode, so do members of the balsam family, and a cress as well as a spurge. One plant allied to the mistletoe is able to throw its seeds right on to another tree. The squirting cucumber, if touched by an unwary person, is apt to discharge the contents right in the face. None of these, however, proceeds with such vigor and regularity of division as "The Monkey's Dinner-Bell." When we think of the hurry and decision with which the *Hura* gets rid of its offspring, we fall into a spirit of "philosophy," and wonder how it is that the cocoanut palm not only provides its seeds with an almost impenetrable covering, but drops them gently at its very own feet. This instance is exactly the opposite of the one already quoted, and affords a good example of the diverse plans and methods of nature.

The *Lecythus* and *Anagallis* also explode in order to liberate their clusters of seeds.

THE LACE-PLANT.

There comes to every one who really loves Nature a feeling of almost ecstatic delight when he sees for the first time one of her attractive products.

The lace-plant is one of these products which give rise in a very marked degree to these pleasant sensations. A piece of bark is stripped off the branch, one end is opened out and opened out until you wonder how many more foliations are coming. You arrive at a stage when you find you have a layer or layers as thin as a sheet of note-paper; but it is still capable of division until it approaches the texture of very fine muslin.

The thin piece of bark can be separated into twenty or more layers, and then you have a light object that would do well for dusting furniture, but it would be a sacrilegious act to turn it to such a degrading purpose. It deserves a place with your most costly treasures, although its price in Jamaica was less than sixpence.

The native women of the island are expert in carrying the opening process a step or two farther. They take out strand after strand of the fibre and dexterously work them into various articles for wear and for household ornamentation. The spinning of the thread that is necessary in other branches of lace manufacture is not required here, for nature produces the thread ready for use when once it is taken out from its fellow threads that conjointly make up the bark.

This lace-plant, to which botanists have given the name *Lagetta lintearia*, as we have seen, is covered with a bark that consists of concentric layers of fibres which interlace so wonderfully, that without any great effort each layer comes off like a piece of lace from a number of pieces of lace pressed together, as it were. It facilitates the removal of the thin foliations to soak the bark in water.

There is authority for saying that King Charles II. received as a present from the Governor of Jamaica a cravat, a frill, and a pair of ruffles made by the natives of this material; and, to this day, it is made into nets for the hair, caps, bonnets, veils, collars, and other articles of apparel. In fact, samples of several of these articles may be seen in the largest of the museums.

It must not be imagined that the lace-bark fibre is delicate and fragile, for it really possesses great strength, and is more durable than several fabrics produced from spun thread. Sloane says that complete dresses for ladies have been made from this very bark, and that Legatta cloth has been imported under the name of Guana.

Of course, the number of laminæ into which the bark is capable of division depends on the age of the tree, probably each foliation corresponds with a single year's growth.

With ordinary care all the manufactured products we have enumerated may be washed and bleached.

Unfortunately there was a time when this natural lace was turned to an ignoble purpose. It was used in the

manufacture of thongs for whips, with which the negroes were beaten by their cruel taskmasters.

The lace-plant is often cultivated as an object of interest and curiosity. We must not leave the subject at this point without a few particulars as to its botanical qualifications. It is a small tree of the Spurge Laurel kind. The name given to the family is not much of an improvement upon any of the other names in favor with botanists—viz., the *Thymelæceæ*. It is known by its “perfect flowers,” so we are told. For my part, I thought all flowers were perfect, for even Solomon in all his glory was not arrayed like one of them. It has a tubular perianth beautifully colored, eight stamens, and a small, round, hairy fruit enclosed in the persistent base of the perianth. It grows on limestone rocks, and inserts its roots into the fissures. It has broad, rounded leaves, and its flowers are like those of the lily-of-the-valley.

This property of splitting up into leaves, resembling the leaves of a book, is not confined to the lace-bark, *Lagetta*. Quite a large number of trees produce bark which can be made into clothing. In tropical countries the natives frequently take advantage of this, and produce materials that have all the appearance of having passed through the loom.

Nowadays several kinds of bark are made into ropes, paper, etc. Any museum with a fair collection representing economic botany is bound to have specimens of bark used in such manufactures.

Beautiful lace work has been made by Irish women from the fibres of the nettle and of the convolvulus. But this opens up a wide domain of trees and small plants, cocoanuts, the flax-plant, and a host of other members of the vegetable kingdom, which by their fibres, husks, pods, or even their stems, contribute to man's comfort by supplying the raw materials in a lavish and yet mysterious manner for the purposes of manufacture.

Among the strikingly beautiful things of the earth must be classed in a very prominent position the bark of the lace-plant, *Lagetta lintearia*.

THE TEASEL OR TEAZEL ("DIPSACUS").

The teazel can perform a duty which no machine, however delicate or accurate, can do half so well. The genius of the nineteenth century produced appliances innumerable and wonderful, both in time and labor-saving; but, so far, the teazel defies imitation and is incomparably superior to any machinery, whether American, German, or English. No machine has yet been invented to supplant it. If any man can make artificial teazels, having the same elasticity, flexibility, and other qualities as the fruit-heads of this plant and at a trifling cost, he can win a name and a fortune.

The dried, thorny fruit-heads of the teazel are in demand wherever cloth is manufactured. It is apparent, therefore, that enormous numbers are required. Many millions of them are used annually in England alone. The demand is so great that over twenty million teazel-heads have to be imported from the south of Europe, France, and Germany, to supplement those grown in the West of England.

In the factories the teazel-heads are methodically arranged upon cylinders which revolve over the cloth so that the hooks of the teazels come in contact with the cloth and raise a nap which is subsequently cut level.

Wire cards and various other toothed contrivances have been tried, but they are more or less unyielding when the slightest obstruction occurs in the cloth, and a rent is the result.

The teazel is more yielding and, if it could bring reasoning powers into play, we should say it is more considerate, and rather than wound the susceptibilities of the beautiful material it sacrifices one of its awns or hooks so that the cloth should not be torn. Self-sacrifice, if not always appreciated, has in the case of the teazel a high commercial value. It will be no easy task for man to make a machine, however automatic, that will be endowed with this additional quality of self-abnegation.

When the purple flowers wither, the heads with portions of the stems attached are dried and assorted into sizes to suit customers. According to their quality and

sizes, they are known as "kings," "queens," "buttons," etc.

The teasel grows in the south and west of England by the hedge-rows and on waste ground. The plant requires two years for perfect growth. Its whole surface is covered with prickles. The leaves grow in pairs, and are so united at their bases as to form a deep receptacle for holding water. It was owing to this cup-like structure that it was considered a thirsty plant. Hence its generic name, *Dipsacus*, from a Greek word signifying to be thirsty.

The *Dipsacus fullonum*, the Fuller's Teazel, is thought by botanists to be a variety of *D. sylvestris*, the Common Teazel, which grows in the south of England, Ireland, Central and South Europe, and parts of Asia. And the only apparent difference from *D. sylvestris* lies in the fact that the scales or thorns of the fruit-heads of *D. fullonum* are hooked instead of straight.

The teasel reminds us that we must not despise the unattractive in nature. There is hardly a plant more uninviting. Leaves, stems, and fruit-heads are all covered with sharp thorns, like so many fixed bayonets which appear to mean both defence and defiance; yet, in its usefulness to the manufacturer and consequently to almost everybody, for most of us require cloth, it stands unrivalled.

THE PITCHER-PLANT.

The insect-catching plants are among the most wonderful representatives of the vegetable kingdom. They are not by any means limited to the use of pitchers in their modes of capturing insects. The *Dionæa* and the *Drosera* have no pitchers.

There are at least thirty species of *Nepenthes*, all of which have pitchers. Each pitcher has a lid, but the function of the lid is not to act like a trap by falling over the mouth of the pitcher. It acts as an attractive surface, both by its color and its honey secretion. The lip is covered with large glands which also secrete honey, so that insects are led from the lid to the lip. The lip is

curved inwards at the edge and downwards, thus preventing the return of any insect that enters the pitcher. The inner surface of the pitcher below the lip is slippery, and in some pitchers, as that of the *Sarracenia*, it is covered with hairs pointing downwards, presenting an impassable barrier to any insect's return.

A digestive fluid is always present in the pitcher. It is a secretion from the glands of the inner surface, and contains a gastric ferment analogous to that of the members of the animal kingdom. The plant thus captures insects, and digests and assimilates them. Analyses of this liquid and of that of the stomach of the animal show no appreciable difference. On this question of digestion a line of demarcation cannot be drawn between the animal and the plant, but it rather serves as a bridge connecting the two kingdoms.

The question naturally arises, in what manner does the accumulation of putrid matter arising from the dead bodies of insects arrive at the roots for nutritive purposes? I believe it was Lord Avebury who found in the *Dionæa* of North Carolina and in other plants, a channel leading directly from the leaf to a point over the roots, along which the products of digestion pass; and that this same great authority was further rewarded in his researches with the Pitcher-Plant, *Sarracenia*, to which I have just referred, in discovering the actual constructor of this remarkable channel.

Large numbers of flies are drowned in these pitchers, and form a putrescent mass, in which the grub of an insect finds abundant food for itself while it is furthering the digestive processes of the plant. The grub in time is ready for changing into the pupa stage, and sets about boring a hole through the plant, along which it is to escape to the earth. This channel remains, and whenever it rains, the accumulated products in the pitcher become sufficiently liquid to pass along it and on to the roots. It is worth noting that the insect makes the passage just before the flowering time of the plant arrives, when the plant most needs nourishment.

It is evident that the duty of the pitchers is to supply

extra nourishment for the growth of the flower and fruit. In tropical climates they also help to reduce the number of insects.

VENUS'S FLY-TRAP.

A plant which the great Charles Darwin says "is one of the most wonderful in the world" must be well worthy of our notice. Unfortunately it is not easy to obtain specimens for observation, as its home is limited, so far as we know, to the eastern part of North Carolina. But Canby in America, and Hooker, Darwin, Lord Avebury, and Burdon Sanderson in England, have given a great deal of time and attention to the study of this plant—with exhaustive experiments—and they have placed within our reach a vast amount of information about the *Dionæa*, all of which is intensely interesting and invaluable. One can hardly imagine that such a tiny plant should absorb the special attention of such great and learned authorities. Therefore while appreciating their work, we ought to learn the main particulars, at least, of this important member of the vegetable kingdom. "The rapidity and force of its movements" place it in its unique position among other plants.

In the case of the *Drosera*, the captured insect, in the first instance, is held by a glutinous secretion and is gradually embraced by the tentacles or arms of the plant. But the behavior of the *Dionæa* contrasts with this, in that its movements are more like that of a rat-trap. At the end of each footstalk there is a two-lobed leaf, the lobes standing at rather less than a right angle to each other. It is between these lobes that the insects are captured. The edges of the lobes are prolonged into spines. "Three minute, pointed processes or filaments, placed triangularly, are projected from the upper surfaces of both lobes." These have been proved to be sensitive points, contact with which causes the lobes to close rapidly. These little pointed processes stand in such a position that, when the lobes close, they interlock. "The upper surface of the leaf is thickly covered, excepting towards the margins, with minute glands of a reddish or purplish

color, the rest of the leaf being green. They secrete, but only when excited by the absorption of certain matters."

When an insect touches the sensitive hairs, the lobes press quickly and closely together, the glands are brought into contact with the insect, and secretion commences. This secretion is acid, and contains a digestive ferment. The leaves remain closely shut for many days, and after expanding again are torpid. The power of digestion is limited; the leaves cannot digest more than two or three times in their life.

"*Dionæa* is looked upon as the most highly specialized of Insectivorous Plants, its sensitive hairs serving as organs of touch, its lobes for capture, and its glands for the consumption of its prey, while in the *Drosera* the tentacles effect all these ends."

THE HOP-PLANT.

There are several curious and interesting particulars connected with the hop-plant which are well worth mentioning. Nature has not provided all plants with thick, rigid stems capable of giving them sufficient support to stand alone in the battle of life. A great number of them, not having inherent strength to be independent, require external support, and are known as *climbing plants*.

In dense forests and jungles plants with weak stems would fare badly as regards sunshine, were it not that they are endowed with special facilities for attaining to great heights. This is accomplished, too, by the expenditure of very little in the way of material and in a variety of ways.

Some are *twining* plants. The whole of the plant twines round the supporting agent. One of the most graceful of all twining plants is the Hop. This plant in climbing round its support takes the same direction as the hands of a clock—describing a right-handed helix. It is provided with longitudinal rows of tiny hooks, which give support to the plant. These hooks render a great service, because, as the foliage increases and hop-heads appear, the upper parts of the plant becomes heavy, so that something more than the delicate stem is required to enable

the plant to reach the sunshine, and to attain to its full maturity and prolific condition. The important function, therefore, of those little hooks becomes apparent.

The growth movement of a climbing plant is called its nutation. Wherever the plant or its tendril touches the object on which it is climbing, the stimulus of contact causes the side away from the object to grow more rapidly than the other, and in this way the plant or its tendril commences to curve round its support. It appears from this that plants are sensitive to continued contact, and that they move in response to such stimulus. This constantly brings new surfaces into contact, and causes the twining of the plant or of its tendril. We cannot fail to notice at this point how very closely the plants approach by their sensitiveness the members of the animal kingdom. The sense of touch seems to be very much of the same nature in both kingdoms.

But to return to the hop. The hop has a perennial root and annual stems. The male and female flowers are generally on separate plants. The male flowers are in loose tufts, but those of the female are in dense catkins with membranous, irregularly developed leaves or bracts. The hops of commerce consist of the female flowers and seeds. Numerous little, yellow, shining, resinous grains are to be seen on the bracts, which give out an aromatic odor. They are known as lupulinic glands, and are believed to be the most active parts of the hops.

The hop possesses both tonic and hypnotic properties (that is, power of inducing sleep). Pillows stuffed with hops are sometimes used with success in cases of sleeplessness. From the brewer's point of view the plant possesses several qualities which make it valuable to him in the manufacture of beer. First, in malt liquors, hops exert a chemical influence that preserves them from turning sour by checking acetous fermentation. This quality renders the beer capable of being kept. Secondly, the tannin of the hops by precipitating the albumen of the barley clarifies the beer. Thirdly, they give an aromatic flavor to the beer. Then, fourthly, comes in the question of *headiness*. Owing to this property the brewer need

not use so much of his malt. But apart from the purposes of brewing, hops are often prescribed as a tonic. John Gerarde, a botanist, surgeon, and quaint writer of Queen Elizabeth's reign, says of this plant:—

“The hop joyeth in a fat and fruitfull ground, also it groweth amongst briers and thornes about the borders of fields. The flowers are used to season beere or ale with, and too many do cause bitternesse thereof, and are ill for the head. The manifold vertues of hops do manifest argue the wholesomenesse of beere, for the hops rather make it a physicall drink to keep the body in health, than an ordinary drink for the quenching of our thirst.”

We are not all likely to accept his statement that hops make the beer “a physicall drinke to keep the body in health,” but we must agree with him that “too many do cause bitternesse thereof, and are ill for the head.”

In the time of the Romans the hop was a garden plant, and the young shoots were eaten as we eat asparagus. It was first used in England for brewing purposes in the reign of Henry VIII. Its introduction quite supplanted the use of the tender shoots of the broom that were used to give the bitterness so much desired.

In the third year from the date of planting, the hop-plants grown from root sets come to perfection. The young shoots appear towards the end of April, and the plants are in full bloom and ready for picking towards the end of August. The hops are spread out in the oast houses, and dried on a strong hempen or hair network, which allows the free passage of hot air. The process of drying takes from twelve to twenty-four hours. When dried they are placed in the stove-room, where they are fumigated with the fumes of flowers of sulphur. They are then ready for packing in bales. This is accomplished by a screw-press.

Hop-poles varying in height from ten to twenty feet are used for supporting the hops. When the hops are ready for picking, the stems are cut through about a yard from the ground, and the poles are pulled up so that the hops may be readily picked off by hand.

In F. E. Hulme's beautiful work, *Art Studies from*

Nature, he chooses the hop-plant for a wonderfully graceful design, set in two overlapping equilateral triangles, in which he makes a number of hop-heads fit into three angles, alternately with hop-leaves occupying the three angles between. For purposes of ornamentation, either in wood, stone, or plaster, its adaptability is all that could be desired. He mentions that the capitals of Southwell Minster afford a practical example of what may be done in this direction.

With regard to the way in which a plant climbs around a support, we say the hop twines in the direction taken by the hands of a watch, and the convolvulus twines in an opposite direction. These statements are not so convincing as they may appear at first sight. What right and left twining means often gives rise to a great deal of argument. But the matter can be easily settled in the following manner: Place a watch on its back on the table, then put a walking-stick standing upright also on the table. Begin at the lower end to twine a piece of cord round the stick in the same direction as that taken by the hands of the watch. The cord will exactly represent the twining of the hop.

SCHUBERTIA GRANDIFLORA.

The original home of this remarkable plant is Central America. It thrives, however, in our own country. It is a climbing plant and may be purchased for a few pence at any of the large nurseries. Its lovely white blossoms appear in July, and they depend so gracefully on their stalks that they remind one of bursting rockets. Every person who examines the details of the flower expresses astonishment as they are unfolded.

The plant is nearly four feet high, and its long twining stalk is covered with very fine hairs. Its white blossoms are quite two inches in diameter, and are frequently mistaken for those of the *Syringa*. They yield a delicious perfume. But to come to the point of greatest interest for my purpose and one which might be looked upon as trivial and superficial by the learned botanist: Take a blossom and remove

the five petals that form the corolla, and you will now have a bulb-shaped calyx attached to its stalk. Proceed to fold back each sepal, and, on looking straight down upon the inner portion, a regular five-sided device appears with a raised centre, having a close resemblance to a tiny ball of ivory not quite so large as a pea. To use an architect's phrase, we have so far been examining the *plan*. Let us look at its *elevation*. Hold it up and look at each corner of the pentagon, and at once the exact counterpart of the features of a venerable gentleman will be seen. Rotate it, and five similar faces will appear, the left eye of one face acting also as right eye for the next face. The top of the head is as smooth as the proverbial billiard ball, the forehead is wrinkled, the eyebrows are projecting, the eyes piercing from their sunken orbits, the nose prominent, the cheeks receding and lined, the long white beard is perfect, and the proportions of the head are apparently correct.

"Wonderful!" "lifelike!" and "startling!" are some of the exclamations of those who see this object for the first time.

The form of the human face is fairly well shown on the carapace of the "mask" crab and on other objects in nature, but this is not merely a case of one or two points of resemblance to a human head. It has all the appearance of a head proportionally reduced to very small dimensions.

Some one may say: "Explain the reason for all this." This is too much to expect. It is easier to ask questions about nature than to answer them. The aim in view in putting together brief descriptions of a series of curious products of nature is to draw attention to them and to cause an interest to be taken in them, in the hope that our readers may see that nature is stranger than fiction, and that they may find in nature ample material for absorbing research.

RIELLA.

The Riella is a graceful little water plant, spiral in form, and only two inches long. It is one of the mosses.

The mosses are not generally looked upon as yielding any particular benefit to man. One writer says: "They perhaps yield fewer objects of utility to man than any other division of plants, except those of the same alliance. In agriculture and in the garden, though of small size, they are often noxious weeds."

Surely the mosses make the landscape more beautiful, by affording a rich covering for old ruins and walls and trunks of trees. And do they not add largely to the material required for the formation of peat, and cannot peat be used in more than a hundred serviceable ways? Do they not collect and hold water in large quantities? This is to me a striking point in their favor, especially in warm climates. They seem to fulfil an unusually important office in the economy of nature. Mosses are to be found in all parts of the world, even on mountains, at heights where all other vegetation ceases, and in the depth of the forest where vegetation is most prolific. One of their functions is to collect the rainfall like so many sponges, and as they form a thick covering on the trees, they retain for them that moisture which would otherwise rush away in torrents.

Then again the disintegration of many rocks and the consequent formation of humus, or mould, is brought about by the action of mosses. The seeds of the higher plants by taking root in this congenial mould are thereby indebted to the despised mosses.

To the microscopist the mosses are always attractive for their marvellous structure and beauty.

The *Riella*, although one of the mosses, is classed low down among the liverworts. In most liverworts the plant has a definite leafy structure, but in the *Riella* we have an exception. Instead of leaves, it is endowed with a beautiful membranous wing about the fifth of an inch wide. This wing is of a pure green color and of extreme delicacy. It turns spirally on a central axis, forming a winding screw, and reminding one of the staircase up the tower of Exeter Cathedral. The central pillar in the staircase corresponds to the ribs or axis of the water-plant. As the membranous wing turns round it has the

form of a cone inverted. Although the plant is only two inches high it is looked upon as one of the most remarkable in the whole of the vegetable kingdom.

All the mosses, with this single exception, grow horizontally, but the *Riella* grows upright, and is one of the few that grow in water. In fact, it comes to perfection completely under water.

It is attached to the ground by clasping roots known as rhizoids.

A distinguished soldier and botanist, Durieu de Maisonneuve, was the first to discover and describe this plant. He found it in Algiers.

The shape assumed by the plant is what is termed a right-handed helix. There are many instances of the spiral in Nature.

HOW PLANTS TRAVEL.

BY

THE SCIENCE EDITOR OF "THE STANDARD," LONDON.

RAMBLING over the South Downs, in England, in late summer or autumn you may often see the short, smooth turf veiled with a soft, moving mist. It is the down loosened from the ripened heads of the little dwarf plume thistle floating about in the breeze. So it sails along hither and thither, until it finds a resting place where it may grow and reproduce its kind. Sitting in this garden, again, which here slopes down to the willow-fringed river, the south wind wafts toward you the soft white down of the willow's ripened seeds. Thus making the wind their travelling car, many plants travel round the globe. The seeds of the locust tree have been carried from Africa to Italy. On April 24, 1897, a thunderstorm passed over the latter country. Mingled with the rain there came the sand of the African desert and the seeds of the locust tree. The familiar dandelion is one of the greatest wind travellers. Each seed, surmounted by a little delicate par-

achute, is admirably adapted for an aërial voyage. Crossing rivers, seas, and mountain ranges, it has traversed the wide world. With the adventurous Peary it has entered the Arctic regions and with the sailor it has crossed the equator, appearing in both northern and southern hemispheres. The Rose of Jericho utilizes the wind in a peculiar way in seeking "fresh woods and pastures new" for its offspring. It is an annual, growing in dry, sandy places and as its seeds ripen the leaves wither, and the branches dry up and curl inward. A ball is thus formed, inside of which are the seedpods. This is soon loosened from the sandy soil and becomes the plaything of the wind. In the deserts of Syria and Egypt many of these balls may be seen drifting about. When the rain comes they uncoil and the seeds may germinate. The "Wind Witch" of the Russian steppes is a plant which travels in a similar way. This is a sort of thistle which, after flowering, curls up into a ball. Then the stem rots off and the plants start off on the wings of the wind. There they go, careering over the plains, outstripping the swiftest horseman. Now they rise suddenly into the air, hopping and dancing along in erratic and fantastic courses. Sometimes two hook on to each other and go spinning off together. A dozen more join them, and the mass rolls lightly along before the brisk east wind. Some day, at the gentle invitation of the rain, they will uncoil and the seeds grow.

As you wander by the clumps of furze and broom in August and September a little sharp crack! crack! resounds on every side. It is the bursting open of the seedpods and the scattering of the seeds. Each pod, in fact, is a little gun, and the seeds are the bullets. The contraction of the pods by drying is the firing of the gun. The outside of each division of the pod contracts most and tends to curl outward. In time this force overcomes that which keeps the divisions of the pod together, and they spring apart. The seeds are thus shot out. Cranesbills, or native wild geraniums, adopt the principle of the sling. You can illustrate the method thus: Hold a stone in each hand, the arms being held down to the sides.

Raise the arms sharply, and at the same time open the hands. The stones fly out to some distance. This is precisely how the geranium scatters its seed, only it has five arms instead of two. Examine a ripe head of seeds. The five seeds are arranged at the bases of five arms round a central axis. The outsides of these arms contract more quickly as they dry than the insides, and this gives them a tendency to curl outward. This is restrained by the attachments at the bases, until the force is sufficient to break them. Then the arm flies suddenly out and throws away the seed. Selecting a seed at the right stage and giving it a little assistance, you may see the slinging away of the seed yourself. The seed of the dandelion may blow anywhere and not infrequently reaches places where the young plant cannot grow. In other plants, however, there are special provisions for getting the seed into a suitable place. The mangrove is one of the most interesting of these. It grows in salt-water swamps and shallow sea water, and the young plants require to be rooted in the mud. If the seeds simply fell and floated on the water they might be carried out to sea and perish. To meet this difficulty the seed begins to grow while still on the tree. It sends out its embryo root in the form of a thick, solid spike, eight or ten inches long, and pointing vertically downward. When the seed falls its weight carries it to the bottom of the shallow water, and the spike is driven firmly into the mud. The young plant has set itself and has simply to go on growing. Two interesting examples occur in the British flora. The pretty little ivy-leaved toad-flax, which grows on old walls, wants to lodge its seeds in the hollows and cavities of the mortar. But it must needs keep its flowers on the outside to bask in the sunshine and spread a banquet for the bee. So, as soon as the flowers give place to seeds, the flower stalks turn right back and carry the seedpods inside, so that they may shed their seeds into the wall. And then there is that pretty water buttercup, or crow-foot, whose white flowers star the ponds in spring. Its seeds must be sown in the mud at the bottom of the pond. So, as soon as the flowering is over, the stalks turn right

over and carry the seeds down into the required germinating place.

The mangrove is not the only plant in which the problem of dispersal is solved by the seeds beginning to grow on the parent tree. In East Africa there is a tree known as the Nyika, the seeds of which germinate on the parent plant. Here it is the seed leaves which grow first instead of the root. These form a sort of parachute by means of which the young plants are wafted through the air to suitable spots. Some plants prefer to do their travelling by sea. If they are good sailors, that is, if they can float and stand long immersion in salt water, this is a very effective way of reaching the ends of the earth. Thus the seeds of a West Indian plant have been picked up in the Hebrides, having travelled there on the Gulf Stream. They have even been picked up on the bleak shores of Spitzbergen. In these cases the locality has proved unfavorable, but they show how far plants may travel in this way. Cocoanut palms fringe the shores in tropical regions. Blown from the trees, the cocoanuts float about in the waters. And when, through the labors of the coral polyp, or the exertions of the submarine volcano, a new island rises in the ocean, then, sooner or later, one of these ocean waifs lands on its shores. It takes root and grows, is joined by others, and presently the new land has its fringe of palm trees. The great double cocoanut, the Coco-de-Mer, was known as an ocean traveller long before the discovery of its native land among the Seychelles. Stranded on bleaker Northern lands these travellers from the tropics have not lost their power of germinating. The "sea-bean," a waif from the West Indies, often cast on English shores by the Gulf Stream, has been raised in Kew Gardens from seeds picked up on the Azores. Linnaeus, the Swedish botanist, again knew of cases in which plants had been reared from seeds of tropical plants cast ashore on his own Northern land. The seeds of other plants are provided with hooks or bristles, by which they adhere to the fur of animals. Among English plants, burdock, common oats, and goose grass travel in this way. The wool staplers of Elbœuf, in France, used to find seeds

of medicaga entangled in the fleeces which they imported from Brazil. On being sown, these seeds, in spite of their long journey, were found to grow. Other plants travel with the birds. And since in their annual immigrations many species cover immense distances—in some cases from North Polar to South Polar districts—seeds may be scattered far and wide by their means. Again, one of the most puzzling facts in the botany of Ireland is the occurrence of one or two American plants. And at rare intervals certain species of American birds are shot in the same country. Put these two facts together, and the former is, perhaps, explained.

THE NORTH AMERICAN FOREST.

BY

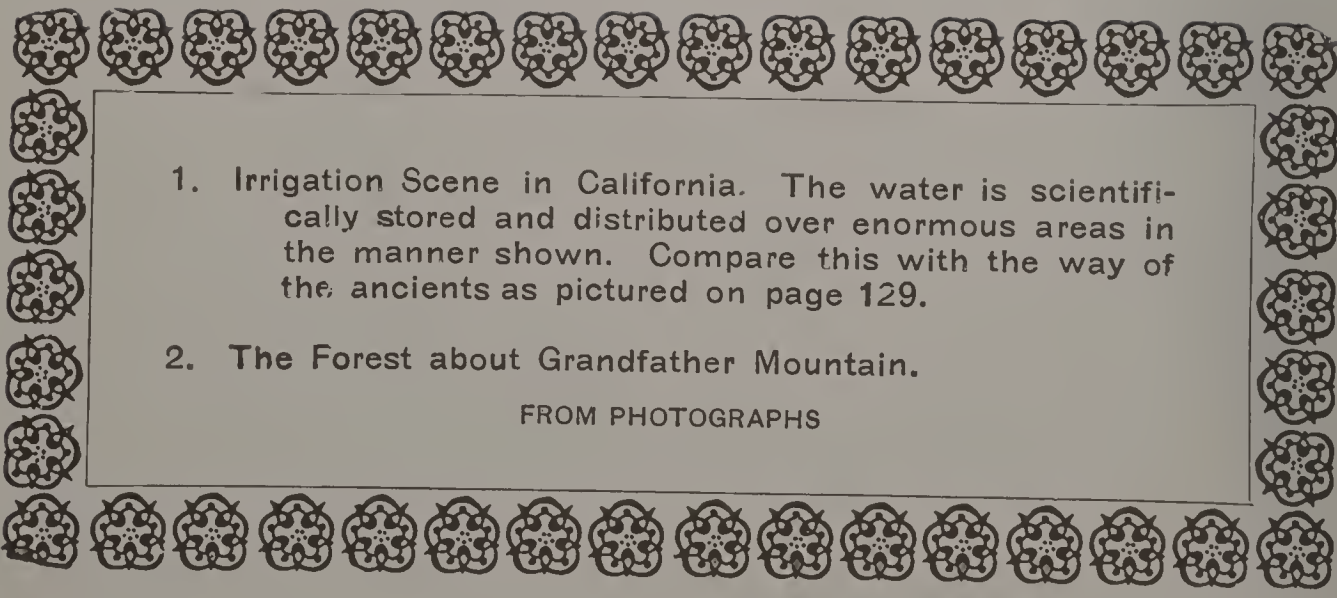
ERNEST BRUNCKEN,

SECRETARY OF THE LATE WISCONSIN STATE FORESTRY COMMISSION.

THERE are in the northern temperate zone three great forest regions: The eastern Asian, including principally the eastern portion of Siberia, Manchuria, and the Japanese archipelago; the European; and the American forests, including great portions of the United States and Canada. The American forest may be subdivided into three groups: The great eastern forest, which originally covered nearly all the territory on the Atlantic side of the Mississippi, and in several places extends considerably beyond that river; the forests of the Rocky Mountain regions, including the minor mountain ranges of the great basin; and the Pacific coast forest. The immense areas lying between these subdivisions are occupied by the grass plains of the eastern slope and the alkali and sage-brush deserts of the interior, both of them distinguished by the almost total absence of tree growth. On the northern edge these three forest zones

converge, so that there is a subarctic forest belt stretching from ocean to ocean. We have before us the task of describing the relations existing between the life of the American people as a social organism, and the forest with its manifold productions. It seems natural to begin by considering the characteristics of the forests themselves, such as they were before the hand of man wrought the vastly changed conditions under which they now exist. In doing so we cannot think of delineating in detail the botanical or physiographic phenomena of this great form of plant life. He who would learn of the different species of trees composing it, their dendrological character, their manner of life and growth, will have to look elsewhere for such information. Nor will we have space to wax eloquent about the beauty of our sylvan inheritance. Although the esthetic point of view has its very important place in our relations to surrounding nature, we cannot in this volume concern ourselves with that aspect. What we in this chapter seek to impress firmly upon the minds of such as may feel inclined to follow the author through these pages is simply this: the manner in which the various trees are associated in the wilderness is not the result of accident, but determined by complex, but very definite laws. If one had a perfect knowledge of those laws he could predict with absolute certainty the number, species, and character of the trees to be found in any given locality. And further: the forest is not a thing that was made once and remained the same ever after. It has grown and developed as a whole, just as each individual tree grows from infancy to old age. Again, this growth and constant change takes place according to very complex and unalterable laws. Each tree does not constitute an independent entity, but is affected in every moment of its life by every other tree and minor plant of the entire forest, and in turn itself influences every other tree. The forest therefore constitutes an organism, having a united life different from, but dependent on, the life of its individual members. Within this organism, a never-ceasing struggle is going on, tree fighting against tree, species against species; while the





1. Irrigation Scene in California. The water is scientifically stored and distributed over enormous areas in the manner shown. Compare this with the way of the ancients as pictured on page 129.

2. The Forest about Grandfather Mountain.

FROM PHOTOGRAPHS

entire organism carries on a warfare with other plant associations, such as the prairie and the bog, in which it is sometimes vanquished, sometimes victorious.

To the ingenuity of man, with the help of such knowledge as he may acquire of the laws regulating the life of the forest organism, it is possible to make use of the various phases of this warfare for his own purposes. By creating conditions favoring some particular species of tree he is able to help it to spread and flourish at the expense of its competitors; and similarly he may create conditions which help the forest as a whole to maintain itself against the aggression of other plant associations. No small part of silviculture—or the art of caring for woodlands—consists in just such interference in the natural processes of forest development, rather than planting and sowing. In order to understand the relations of forestry to our national life, the reader should have in his mind an outline at least of what American forests are like, and also of how they came to be what they are.

Each of the three main subdivisions of the North American forest has peculiarities distinguishing them from the others. Let us first look at the great Atlantic region. This immense territory was, when white men first came to our shores, almost uninterruptedly covered with forest. For thousands of square miles, in many portions of it, there was not enough open space to establish a forty-acre farm on. There was an occasional strip of sedge-covered marsh along the streams; an open bog had here and there taken the place of a former lake. The few small clearings made by the Indians were hardly worth counting. Thus the interminable woods extended from the salt meadows of the tide-water line to the Appalachian Mountain chain, swept up its ridges and peaks, leaving bare but a few of the highest tops, filled the broad longitudinal valleys, and descended into the great rolling plain of the Mississippi country. But here its character changed by degrees. More and more frequently the vast continuity of it was interrupted by prairies, grass-covered and flower-studded, many of them of vast

extent. Towards the north, to be sure, in what are now the northern portions of Michigan and Wisconsin, Northeastern Minnesota, and especially the immense territory between the Great Lakes and Hudson Bay, there are no prairies. The dense unbroken forest, the "heavy timber" as it is called by the people of the locality, is there bounded quite abruptly by the treeless expanses of the Great Plains, where the miserable inhabitants talk of a forest when they see a few willow shrubs and poplars in a ravine by the river. But farther to the south, there was a large region where forest and prairie struggled for mastery, with the result that, generally speaking, the prairies covered the undulating uplands, sedge marshes the wet, broad depressions, and forests the river valleys, as well as the few hilly places. There were also light groves, called openings, in many places in the uplands.

The species constituting this great area of primeval forest were far from being the same in all parts of the territory. Far to the north, on the bleak shores of Hudson Bay, hardly anything was found except spruce (*Picea mariana* and *P. canadensis*), together with the balsam poplar (*Populus balsamifera*). As you go south, the first additional trees you meet with will be the little jack pine (*Pinus divaricata*) and the aspen (*Populus tremuloides*). Soon you enter the domain of the king of lumber trees, the stately white pine (*Pinus strobus*), with her cousin, the misnamed Norway (*P. resinosa*), and the dignified, slow-growing hemlock (*Tsuga canadensis*). By this time you are fairly within the realm of the broad-leaved trees, the oaks, maples, beeches, chestnuts, the walnuts and hickories, the tulip tree and sassafras, the gigantic sycamore, or buttonwood as they call it in the Eastern States. The farther south you go, the greater becomes the number of species, until when you reach about the latitude of Kentucky or Southern Illinois the list becomes so long that it would fill several pages of this volume. Here and in the region of North Carolina the eastern forest reaches its greatest development so far as diversity of trees is concerned. Farther south, the

coniferous trees, especially the different kinds of pine, again become more prominent, as they were towards the border of British America. The southernmost end of the region, the extreme southern part of Florida, with the adjoining islands or "keys," takes on a different character, many varieties properly belonging with the typical West Indian species. The most distinguishing feature of the whole region, excepting the arctic edge, is the prevalence of broad-leaved trees. Over very wide areas not a coniferous tree can be seen, unless it be the arbor-vitæ (*Thuja occidentalis*) and tamarack (*Larix laricina*) of the swamps. Elsewhere broad-leaved and coniferous trees grow mingled together, with broad-leaved ones holding the decided majority; while, to be sure, there are also large areas where the pines and their congeners exclude their broad-leaved rivals almost altogether.

But in the other two forest zones, the Rocky Mountain and the Pacific, the coniferous or evergreen trees have almost a monopoly. Not as if there were no broad-leaved species in those sections. There are many, oaks, maples, poplars, and others. But they form little scattered groves here and there, or crouch in the ravines of the mountain streams, without impressing themselves upon the character of the landscape. There is another feature of the western forests, or the larger portion of them, which makes their aspect quite different from eastern woodlands. That is the fact that the trees, in many cases, stand far apart, so that their crowns do not always touch. While in the east the trees, both broad-leaved and evergreen, stand so close together that the branches intermingle and form a dense canopy, through which but few scattered rays of sunshine ever reach the ground, such is not the case in the forests of the Rocky Mountains or the Sierra Nevada. One of the consequences of this manner of growth is that the soil in the western forests becomes much drier than it ever does in the east. This fact will probably have an important bearing upon silviculture when that is begun in earnest in the western country. Another feature distinguishing the forests of the Rocky Mountain region from those of the Atlantic side

is that they nowhere cover such immense areas in unbroken compactness. They are distributed along the mountain ranges in belts, leaving bare the highest portions where reigns the eternal snow, and rarely occupying the broader valleys and plains.

Not only have the pines and other coniferous trees the overwhelming majority of numbers in those western forests; they also display a far greater variety of species, compared with eastern woods. Some of the western species, like the western white pine (*Pinus flexilis*) or the bull pine (*P. ponderosa*), spread over large areas, while others, like the Monterey pine (*Pinus radiata*) or the redwood (*Sequoia sempervirens*), are restricted to a few valleys or mountain ranges. Of the 109 coniferous trees native to the United States and enumerated in Sudworth's list, eighty belong to the country west of the great plains, twenty-eight to the eastern forest, while only one, the common juniper (*Juniperus communis*), inhabits portions of both regions.

What has been said about the peculiarly open character of much of the western forest does not apply to those portions found in the western halves of Oregon and Washington, and thence stretching along the coast into Alaska and far towards the Arctic regions. On the contrary, these are among the densest woods in the whole world, where under the vaults of the immense crowns, that are swung from the column-like trees at a height of 100 or 150 feet, eternal twilight covers the ground. Of all the forests of the world these have the most gigantic trees, barring only the sequoias of California, of which we will speak anon. Compared to the spruces, firs, and pines of the Puget Sound region, the mightiest of eastern pines and even the giant sycamores of Illinois and Indiana river bottoms are but smallish. No one who has entered those dense forests composed of trees 250 feet tall and having six and more feet in diameter has failed to be impressed with their grandeur, and literature is filled with attempts to describe their majesty. But they are surpassed by the redwood (*Sequoia sempervirens*), that magnificent, cypress-like giant which forms a belt,

from ten to twenty miles wide, along the California coast from the Oregon boundary to a point in Monterey County, a little north of San Francisco. And even the redwood is not equal in size to the famous big tree (*Sequoia gigantea*), the pride of the Sierra. This tree is known to tourists principally by the comparatively few specimens growing in the protected groves of Calaveras and elsewhere. But it reaches its grandest development farther south, in the southern part of the Sierra, where it forms, not small groves, but extensive forests.

How did the forests and the species composing them come to be distributed over the North American continent in just the peculiar manner in which we find them? Before very much was known about plant geography, people used to be content with saying that each tree found itself in that region the natural conditions of which were most adapted to its nature. But such vague answers no longer content us to-day. The science of palæobotany, or the knowledge of the plants which existed on the globe in former geological periods, has helped us on the track of this secret of nature. To be sure even now we know these things fragmentarily only, and an almost limitless field is here still open to investigation. But this we can now affirm: The distribution of trees is due to two sets of factors,—one topographical and climatic, based upon the differences of soil, elevation, temperature, humidity, and so forth. The other factor is historical, arising out of the order in which the seeds of different species were deposited in each particular locality, or failed to be so deposited.

The palæobotanists, drawing their conclusions from the remnants of wood, impressions of leaves, flowers, and fruit, and other small relics of extinct vegetation which are found imbedded in rocks and beds of coal or peat, have established the fact that during what are known as tertiary times, vast forests, composed of trees not very different from those now growing in the United States, existed in far northern regions, nearly up to the pole, where now everything is decked with ice and snow. But the warm climate of the tertiary ages was succeeded

by the secular winter, which is known as the glacial period of the quaternary epoch, and of which most of my readers have heard. Farther and farther south crept the great glaciers, joined by those flowing down from the high mountains of the west, until the whole northern part of the continent, as far south as the latitude of Cincinnati, and even beyond, was covered with a sheet of ice of immense thickness, leaving but here and there an island uncovered, like the celebrated driftless area of Southwestern Wisconsin. Before the advance of the ice and the cooling of the climate that was both cause and consequence of the glaciation, the forests succumbed, and the species composing them were either extinguished or became restricted to more southern latitudes. But after thousands of years the climate gradually became milder, the edge of the continental ice sheet slowly melted, forming immense rivers and lakes. As the land was laid bare, vegetation recovered the lost territory step by step. At first, the character of the land recently left by the ice was undoubtedly very much like what we find to-day in the Barren Grounds, the solitary regions in the northern part of the British dominions. There we find vast areas covered principally with mosses belonging to the genus *Sphagnum*, interspersed with a few sedges and numerous species of the heath family. It is a vegetation very similar to that of the peat bogs found occasionally in the Northern States. These moss prairies or tundras were gradually supplanted by the advance-guard of the forest; spruces and poplars, that came slowly marching up from the south and are, in all probability, continuing their advance to this day. These most arctic of American trees were followed by the pines, and these again by the more southern species of hardwood, maples, oak, beeches and the like. While thus the forest as a whole was advancing northward, the various species fought among themselves for each locality. This fight continues to the present day, and is changing the distribution of species from century to century. It is very probable, for instance, that both north and south the hardwoods are gaining ground at the expense of the pines and spruces. The

hemlock does not reproduce itself in a portion of Wisconsin, and therefore will die out there when the present generation of trees has run its course, unless man interferes. The red and black oaks are gradually supplanting the white oaks in many parts of the country.

We have repeatedly used the terms warfare and fighting for the competition of trees among themselves, and it is time to give the reader an idea of how such warfare is going on. Trees have no claws and teeth with which they can attack each other as animals do, but they can fight, nevertheless, and the numbers of the dead and crippled in these battles are tremendous.

There are two things which every tree needs, or it must die: moisture for its roots, to carry water containing in solution various mineral salts to all parts of its body, and light to enable the leaves to assimilate the material so furnished, and build up the various vegetable tissues making up the tree. Each kind of tree, by reason of its specific characteristics, requires these two things in varying proportions. For each species there is a minimum of light, and the accompanying warmth, and also a maximum; exceeding these limits, suffering begins. The same holds true of moisture, as well as some other requisites. For instance, most trees will die if their roots are immersed in water for a large part of the growing season. But a few, like the black ash or bald cypress, will grow lustily on swamps wet the year through. They have a very high moisture maximum. On the other hand, these species would not flourish on a dry, rocky ridge. The conditions there would be below their moisture minimum; while a black spruce, for instance, will grow in a Northern Wisconsin swamp no less than on a dry rock in the Adirondacks, because it is adapted to a very large range of moisture conditions.

As to light, dendrologists have divided trees into two classes, light-loving and shade-enduring species. The two classes, however, connect by imperceptible transitions. Generally speaking, the needs of a tree as regards light can be told by the character of the shade its own crown makes. The oaks, for instance, need much light,

and an oak sapling that stands in a dark, shady place will never grow to be a good-sized, healthy tree. Now, everybody must be struck with the light character of an oak grove, where the sun's rays everywhere penetrate to the ground and paint fantastic figures on the vigorous growth of grass and herbage. A maple grove is much darker, and if you enter a wood composed of beeches or hemlock, you find yourself in almost nocturnal twilight, where no ray of the sun succeeds in reaching the ground. The need of light for the light-loving trees is particularly great in their youth; while on the other hand, the seedlings of the shade-enduring trees often die when they are exposed to too bright sunshine. If the seed of a light-loving tree should fall under the crowns of a group of beeches, it would have very little prospect of growth, while the young beeches would grow lustily. Here is one of the ways in which species of trees carry on their warfare. Suppose that on a tract of land covered with oak, birches, or other light-lovers, the seed of beech, maple, or other shade-endurers should be deposited. The light coming through the crowns of the established species would be sufficient to start the young invaders into vigorous growth; the seedlings would gradually develop into trees, each forming its usual dense crown and casting a deep shade on the ground under it. By and by they will distribute their seeds, some of which will grow into trees, and it will make no difference to them whether they are rooted under their parent species or under the neighboring oaks. In either case, the light conditions are favorable. But with the seeds cast by the oaks things are different. If they sprout under one of their parent species they will grow. But those that come to lie under the beeches do not find light enough, and either do not sprout at all, or soon languish and die. By and by some of the old oaks will perish, from accident or age. In the new growth the beeches already have the majority, and the percentage in their favor is constantly increasing. After some centuries the oaks will have disappeared, and in place of the sunlit oak grove there now stands a cool, shady beech wood. The war has resulted in victory for

the invader. Of course, the light conditions are not the only factors to decide the struggle, else the light-loving trees would long ago have become extinct. It might happen, for instance, that when the seeds of the shade-enduring species reached the place, they found the light conditions favorable all over the locality, but in one half of it the soil or the moisture relations were such that the newcomers could not endure it. Then the result of the war would be, that on one half of the tract the beeches have superseded the oaks, while on the other the oaks remain in undiminished vigor. The conditions affecting the outcome are rarely so simple as we have here assumed for the sake of clearness. Ordinarily, they are exceedingly complex, so that it becomes very difficult to trace them. But a knowledge of these processes is necessary for the skilful pursuit of silviculture. One important practical rule we may mention here, which is based on this observation that the species of tree growing in any given place is not always directly regulated by the natural circumstances of the locality, but influenced by the competition of other species. It is this: The fact that in any region a species is never found except in places of some special character, as in swamps, or on sandy soil, does not prove that it will not flourish elsewhere. It may have been driven into these retreats by its competitors, and would really much prefer the better places from which it has been excluded by them. This may often be of importance in silviculture, when it is desired to grow a tree outside of its apparent favorite habitat.

Just as each species competes with every other species for the most favorable places, so every individual tree competes with every other, whether of its own kind or a different species. Again, the main objects of the struggle are light and moisture. To gain these necessities, each tree adapts its manner of growth, the shape of its trunk, branches, roots, and leaves in a most marvellous manner. Everybody must have noticed that no tree is the exact counterpart of another of the same species. Aside from differences in age and size, each tree has a different way of disposing its branches, twigs, and leaves.

This difference is invariably exactly of the kind which is most favorable to the growth of the tree under the particular local circumstances among which it must develop. As a tree cannot run away, it has to make the best it can out of the situation in which it finds itself as a seedling. Sometimes the devices the tree hits upon in difficulties are absolutely startling. Here is an illustration: At Devil's Lake, Wisconsin, a pine tree is standing on the side of the almost vertical quartzite rocks of the locality. It had originally sprouted in a cleft where there is hardly a shovelful of soil. The tree is now about six inches in diameter. From its little cleft, it sends out a single root, as thick as the trunk, along a narrow ledge, on which there is practically no soil at all. On the surface of this ledge, lying on the exceedingly hard rock, this root runs along, almost horizontally, for twenty-six feet, where it finds an accumulation of soil and enters the ground.

While there are infinite variations of form growing out of this struggle for moisture and light, there are a few general rules of practical importance to the forester. A tree standing in the open, where the light strikes its crown from all sides, forms a round, symmetrical top, with the lowest branches not very far above the ground. Or if it is of the kind that has a pyramidal growth, like the spruces and most other coniferous trees, it may be clothed with living branches to the very earth. If the same kind of tree should grow in a place where it gets full sunlight from some directions, while other sides are shaded, the branches will all, or nearly all, grow towards the light, thus forming asymmetrical crowns. Now suppose that a tree of the same species should find itself standing in a dense clump of trees, where the light cannot reach it from any side. Then its only salvation is to reach the light which comes from above. Consequently it sends out few and small lateral branches, but puts all its energy into height growth, until it has grown above the shade cast by the surrounding trees. This done, it begins to spread its leafy branches in all directions, to absorb as much of the loved sunlight as possible. Where

a number of trees grow closely together, so as to mutually hinder the light from reaching their leaves, a race for the sun ensues between them, in which those are victorious which by reason of their more energetic height growth first show their tops above the others. Then these begin to spread their side limbs, thereby throwing their rivals into ever denser shade, and the latter cease to grow vigorously, and in course of time may even die. If they are of the shade-enduring kind, they have, of course, a better chance to survive than if they were light-lovers. In such a case they may even succeed, after a while, in their turn, in overtopping the first victor, because that ceased to grow much in height when the spreading of the branches began. But generally the tree which has once been overtopped by its neighbor never grows into a very large and vigorous specimen, but joins the ranks of the suppressed, which the skilful forester cuts out sooner or later to make room for their betters.

Not only do whole trees languish and die when they are overshadowed by others, but every branch shares the same fate if at any period of its life it is deprived of the free access of light, either by other branches of its own tree, or by neighboring trees. Where the trees stand close together, this happens to all the lower branches, which usually die and fall off during the first few years of their lives, so that not only are few side branches produced, but what few there are soon disappear again. Trees so grown consequently show tall trunks with only a few branches towards the top.

Now it happens that the quality of lumber cut from trees with tall stems is very much better than that produced by trees where the branches are many and reach far down the trunk, for every branch means a knot in the lumber. Consequently the forester who desires good lumber aims to make his trees tall and with as few branches as possible on the lower part of their trunks.

When the tree has succeeded in growing above the heads of competitors and begins to spread its crown, it changes its economy in various ways. For one thing, as it is now enabled to provide itself with more leaves, it

has a chance to produce a greater quantity of wood: for each leaf is a laboratory where the material is distilled out of which wood and other vegetable tissue are formed. This increased formation of wood results in an increase of the diameter of the trunk, while the height growth is no longer as rapid as before. At the same time, the character of the wood changes, especially in those trees which have two kinds of wood, an inner core of heart-wood, and a surrounding layer of sap-wood. This is the case with most of our lumber-producing trees. The greater the diameter of such a tree trunk, the smaller the proportion of sap-wood, while a tall tree of very small diameter is nearly all sap-wood. As heart-wood is much more valuable for timber purposes, it follows that to make his trees most valuable the forester allows them to follow up the period of rapid height growth by a period of prevalent diameter increase. In other words, he now cuts away the weaker, half-suppressed trees, so that the remaining ones get the benefit of an open stand. Where this happens naturally in the wilderness, by one cause or the other, the result is, of course, the same as where the new condition is produced artificially. The forester's art in silviculture never amounts to anything more than giving special direction to the processes initiated by nature.

One of the principal weapons which trees have in the propagation of their species is the production of immense quantities of seed, which are spread broadcast, trusting to accident that some will find a favorable spot to sprout and grow into a new tree. Evidently, the more seeds are sown, the greater is the probability that some of them will find such a spot. Therefore trees that are very fertile have an advantage over trees which produce a less quantity. But no matter whether few or many seeds are produced, a very small percentage ever succeed in becoming trees. In fact, it happens not rarely that of all the seeds scattered over the ground in any given year not a single one ever reaches the state of a seedling tree. Those who have never observed these relations are apt to assume that in a given tract of woodland, growing

healthily under undisturbed natural conditions, one will be able to find trees of all ages, from the patriarch of several centuries down to the little seedling just showing the tip of its stem above the litter on the forest floor. But such conditions are rather rare, and the reason for that is not very hard to find. In the first place, the trees do not bear seed every year. Varying according to species and perhaps to habitat and other conditions, what is known as a seed year occurs but once in three, four, or five years, as the case may be. In such a year, every tree of the species, old enough to bear fruit at all, is full of them, while in other years only here and there a few are ripening. Consequently it is only in seed years that there is much hope for any seeds to find a favorable sprouting place. But even then it may happen that not one of them has such luck. The condition of the ground has much to do with this. It may be that by one cause or other, as, for instance, too much moisture or too great dryness, it has become unfavorable to the seedlings, either by reason of its chemical or mechanical condition. The older trees are little affected by the change, for they send their roots deeply into the subsoil and the character of the surface layer is of relatively little importance to them. But the seedling depends for its life upon the condition it finds in this top-soil. More often the ground is shaded too much either by the crowns of the old trees themselves or by the undergrowth, which in turn may consist of former generations of young trees of the same species or of shrubs belonging to entirely different kinds of plants. In still other cases the ground may have been invaded by grasses or herbs, forming a matted tangle of roots and stems which make it difficult for the tree seeds to sprout. Under any of these and similar conditions long periods may elapse during which no reproduction of trees takes place, and the supply of many seed years may go to waste. But sooner or later an opportunity will come; and the trees are always on the lookout to take advantage of accidents. One of the commonest of such accidents is the death and fall of one of the giants of the forest. The prostrate trunk for a number of years

encumbers the ground, but it has torn a wide breach into the leafy canopy on top, through which the bright sunlight enters the shady depth of the wood. Gradually the fallen tree decays, helped in this process by manifold fungi and other cryptogamic plants. After a while all that remains of what was once a tree is a heap of rich brown vegetable mould. As yet this is no place for a tree. Only mosses, ferns, and a few flowering plants which like to feed on organic matter and are known to science as saprophytes, or decay plants, find a congenial home here. But gradually, by various processes, among which the burrowing of animals plays no small part, the vegetable mould is mixed with the underlying earth, and true soil formed. Now is the time for the tree seeds, but if they do not hasten to occupy the spot, a host of other plants, herbs, grasses, and shrubs are lying in wait to get themselves established and preëempt the ground. Of course, during the whole time while only fungi, mosses, ferns, and other specially adapted plants could live in the decaying mass, seeds of other species continued to arrive on the spot, but found it impossible to germinate. But now this has become possible for them, and intense rivalry between them follows. In this, if luck is with it, a young tree may come off victorious and in course of time develop into another giant like the fallen one on whose grave it grows.

This is but one instance where an accident afforded opportunity for reproduction of trees in a wood otherwise unfavorable to young growth. Of course the variety of circumstances making such opportunities is infinite. Often it happens in the primeval wilderness that whole bodies of trees are overthrown by violent winds, and then the conditions brought about by the fall of a single tree are repeated on a larger scale. This matter of windfalls is perhaps not quite understood by the average layman. Generally speaking, trees adapt their manner of growth so as to withstand the violence of all winds to which they are likely to be exposed. The means by which they increase their power of resistance to storms are various. One of these is the elasticity of their fibres, even of the

trunk, by virtue of which they bend before the wind, but immediately resume the upright position when the blast ceases. Another means of protection is a root system going very deeply into the ground, combined with great strength of the trunk. Unless the latter quality were added, a strong wind might not be able to uproot the tree as it would a shallow-rooted one, but the very strength and unyielding quality of the root would increase the danger of the trunk being broken off. Still another useful device is the very common thickening of the lower part of the bole just at the place where the greatest strain is suffered when the tree is bent. Now, within the limits set by the characteristics of each species, each individual tree develops these means of defence to a greater or less degree according to the measure of its exposure; that is, a tree growing in a place where strong winds are constantly blowing, as on the crest of a high mountain, develops as deep and stout a root, and strengthens its other wind defences just as much as its specific nature will permit. On the other hand, a tree growing in a protected ravine does not waste energy on such useless objects, but puts it into other forms of life activity. The trees in the midst of a compact forest protect each other, and consequently develop relatively shallow root systems. Only those at the edge of the wood, where the wind can reach them better, send their roots down deeply. Now suppose that, either by the hand of man or natural causes, an opening is made in the forest, so that individuals which heretofore stood surrounded by trees are now exposed to the wind on one or more sides. The trees now forming the edge of the wood will at once proceed to strengthen their root systems and thicken their boles, until they are as well prepared to resist the violence of the wind as if they had grown in an exposed situation from the beginning. But this process takes a number of years, and in the meantime they are in constant danger of being uprooted or broken off. Undoubtedly the majority of disastrous windfalls are in situations like the one described, where the trees had not yet become adapted to new conditions. But it may happen,

of course, that a storm of unusual violence overthrows trees which had bravely withstood all ordinary tempests. The trees sometimes left standing by settlers on their clearings nearly always succumb to the wind sooner or later. Some species, which have shallow roots under the best conditions, are more liable to windfalls than others. Such are, for instance, the basswood (*Tilia americana*) and the hemlock (*Tsuga canadensis*). Others, like the various walnuts and hickories, develop deep and stout tap-roots even in the most sheltered situations, and consequently suffer little from this particular danger. Windfalls are a great detriment to the American forests. In addition to the direct damage, the tangle of drying branches and twigs affords one of the best starting-points for forest fires. The overturned trees are at once attacked by a host of insects and fungi which sometimes spread upon the adjacent sound timber and injure it.

To return to the opportunities which tree seeds find for sprouting, such as are small and perhaps provided with wings, or other devices enabling them to float for awhile in the wind, have evidently a better chance than heavy seeds which cannot fall far from the parent stem. To the former class belong, among others, the seeds of poplars and birches, while conspicuous in the latter are the oaks and hickories. It is impossible to describe here even a few of the wonderful devices by which many seeds acquire this useful power to travel. How much advantage a tree derives from such power of its seeds can be seen conspicuously in the case of the large areas in the Great Lake region which have been deprived of their former pine growth by the lumberman's axe and the fire. On these "slashings" the first trees which appear to provide a new forest growth are almost invariably poplars, especially the kind known as trembling aspen, and the white birches. These have especially effective apparatuses which enable their seeds to travel long distances. The pines, of which there are usually quite a number left on these "slashings," being trees that were too small for the lumberman, or of defective timber, have seeds which

can be carried by the wind but a few rods at best. Consequently they cannot at once cover the whole area, the way the aspens do. But this instance also points the moral that the race is not always to the swift. Though the pines do not travel far, their little seedlings come up in numbers within a few rods about each seed tree. The growth of aspen, as well as bracken, grass, brambles, and other vegetation invading these areas, unless it gets to be too dense a tangle, is of advantage rather than otherwise to them, for it keeps off some of the scorching sunshine to which pine seedlings are rather sensitive. The aspen grows rapidly into saplings six and more feet high. The pines, for the first few years, grow but a few inches. Then they begin to shoot upwards, and by the time they are about fifteen years old, their tops begin to show above those of the aspen, that are now ten to fifteen feet high. Five years more, and the pines are throwing the aspen into shade and hindering their growth; another decade, and most of the aspens have died out because, being light-lovers, they could not thrive in the shade of the pine, which has now recovered the ground it lost thirty years ago. An exactly similar alternation of trees can be observed in New York and New England, with the exception that there spruces usually play the part taken by pines in the Lake region. Undoubtedly other sections of the country might furnish parallel cases where trees have an advantage at the start which they lose later on in the rivalry with other species.

Attentive readers must have observed that the dangers threatening a tree are by no means over when the seed has found a favorable locality and developed into a seedling. Just as very few seeds ever sprout at all, so very few infant trees ever reach old age. A very large old tree takes up a hundred times as much room as a young sapling. This room must be provided by killing off the weaker individuals competing for it. A wood composed mainly of very old trees will show far fewer individuals to the acre than one stocked with young ones. But the crown canopy may be just as dense, and the quantity of timber contained in it is apt to be far higher.

It would require a volume by itself to describe in detail the manifold conditions under which the warfare of the forest is carried on. We have, almost at random, picked out a few of the phases which influence its progress. These illustrations were designed to impress upon the reader the fact that a forest, left to the undisturbed action of natural forces, does not remain unchanged from century to century, but is different to-day from what it was yesterday, and will be still different to-morrow. As the individual tree lives through various life stages, from infancy to old age, so the forest as a whole matures and grows old. But while the individual, when its limit of age is reached, must die, the forest has the power of constantly regenerating itself, so that its continuity may remain unbroken for countless ages. There are, to be sure, certain slow secular changes which may in the long run destroy a forest altogether. Thus the forests growing in the northern half of our continent in tertiary ages were destroyed by the long glacial winter. But that is a matter of many thousands of years. Humanly speaking, there is no reason why a forest, taking its vast extent as a whole, should not live forever.

Another important principle we have tried to impress by our cursory observations on the inner life of a forest: Multifarious and bewildering as the variety of its life phases is, the forest and the changes constantly going on in it are not the disorderly results of accident. In their astonishing complexity they are yet dependent on a few simple laws of nature. To the degree in which we understand these and their workings, to that degree we will be able to control their results. As we proceed in the consideration of the subject-matter of this volume, we will have frequent occasion to treat of the forest as subject, not to natural forces, but to control by the will of man, who may destroy, maintain, or regenerate it as suits his purposes. To understand clearly how such control is possible, we must bear in mind that it is done, not by suspending or reversing the action of the processes of nature, but by guiding and giving special directions to them.

Such guidance and control are possible only to men who have a knowledge of those natural processes. Not as if anybody now possessed or was ever likely to possess such knowledge perfectly. But even an imperfect knowledge gives us a means of exercising some influence. It is only within a relatively short time that a partial understanding of the life processes of a forest has been accomplished anywhere, and in America we are still far from knowing as much of our forests as the Europeans know of theirs. During the greater part of our history, we were very far from exercising an important influence on our forests. On the contrary, our history as a nation was far more intensely influenced and largely determined by the primeval woods.

THE VALUE OF OUR FORESTS.

BY

THEODORE ROOSEVELT.

THE great industries of agriculture, transportation, mining, grazing, and, of course, lumbering, are each one of them vitally and immediately dependent upon wood, water, or grass from the forest. The manufacturing industries, whether or not wood enters directly into their finished products, are scarcely, if at all, less dependent upon the forest than those whose connection with it is obvious and direct. Wood is an indispensable part of the material structure upon which civilization rests; and it is to be remembered always that the immense increase of the use of iron and substitutes for wood in many structures, while it has meant a relative decrease in the amount of wood used, has been accompanied by an absolute increase in the amount of wood used. More wood is used than ever before in our history. Thus, the consumption of wood in shipbuilding is far larger than it was before the discovery of the art of building iron ships, because vastly more ships are built. Larger supplies of building lumber are required, directly

From an Address to the Forest Congress, Washington, D. C., 1905.

or indirectly, for use in the construction of the brick and stone structures of great modern cities than were consumed by the comparatively few and comparatively small wooden buildings in the earlier stages of these same cities. It is as sure as anything can be that we will see in the future a steadily increasing demand for wood in our manufacturing industries. There is one point I want to speak about in addition to the uses of the forest to which I have already alluded. Those of us who have lived on the great plains, who are acquainted with the conditions in parts of Oklahoma, Nebraska, Kansas, and the Dakotas, know that wood forms an immensely powerful element in helping the farmer on these plains battle against his worst enemy—wind. The use of forests as windbreaks out on the plains, where the tree does not grow unless men help it, is of enormous importance. . . . When wood, dead or alive, is demanded in so many ways, and when this demand will undoubtedly increase, it is a fair question, then, whether the vast demands of the future upon our forests are likely to be met. You are mighty poor Americans if your care for the well-being of this country is limited to hoping that that well-being will last out your own generation. No man, here or elsewhere, is entitled to call himself a decent citizen if he does not try to do his part toward seeing that our national policies are shaped for the advantage of our children and our children's children. Our country, we have faith to believe, is only at the beginning of its growth. Unless the forests of the United States can be made ready to meet the vast demands which this growth will inevitably bring, commercial disaster, that means disaster to the whole country, is inevitable. The railroads must have ties, and the general opinion is that no efficient substitute for wood for this purpose has been devised. The miner must have timber or he cannot operate his mine, and in very many cases the profit which mining yields is directly proportionate to the cost of timber supply. The farmer, East and West, must have timber for numberless uses on his farm, and he must be protected, by forest cover upon the headwaters of the streams he uses,

against floods in the East, and the lack of water for irrigation in the West. The stockman must have fence posts, and very often he must have summer range for his stock in the national forest reserves. In a word, both the production of the great staples upon which our prosperity depends and their movement in commerce throughout the United States are inseparably dependent upon the existence of permanent and suitable supplies from the forest at a reasonable cost.

STRANGE TRUTHS ABOUT BIG TREES.

BY

ERNEST HAROLD BAYNES.

THAT "truth is stranger than fiction" is a trite saying, but is one which is particularly apt to come into one's head during a discussion of the great trees of California. If a man had tried, one hundred years ago, to tell an outrageous yarn concerning trees, the size of the trees to be found in some abode of giants, it is altogether doubtful if his figures would have been larger than those which actually represent the size of the great sequoias. And it is certain that his story would not have been more discredited than was the story of A. T. Dowd, the man who first discovered what is now known as the Calaveras grove, and told the simple truth about his discovery.

And we can hardly wonder that he was placed side by side with Baron Munchausen as an inventor of big yarns, when we know the story he told to people who had seen only ordinary trees. He told them that while in pursuit of a wounded bear, he found himself at nightfall in a dark forest. The air was dry and warm, and being weary, he stretched himself on the ground and went to sleep. He awoke about daylight, and when he saw the kind of forest he was in, he rubbed his eyes and pinched himself to make sure he was not dreaming.

He saw all about him monster trees, such as no man had

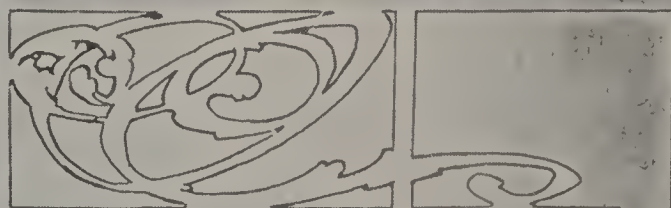
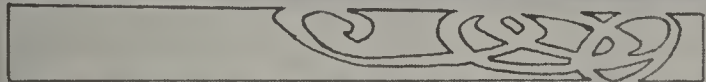
ever seen before. They reared their heads, seemingly into the blue sky, and their enormous trunks, bright cinnamon in color, seamed and ribbed, arose like mighty fluted pillars. The hunter felt as Gulliver felt in Brobdingnag, and half expected to see the huge forms of giants come striding through the wood. He knew that if the tallest church of his native town were set down here, the cross on the pinnacle of its spire would be shaded by the branches as would a doll's house beneath a maple.

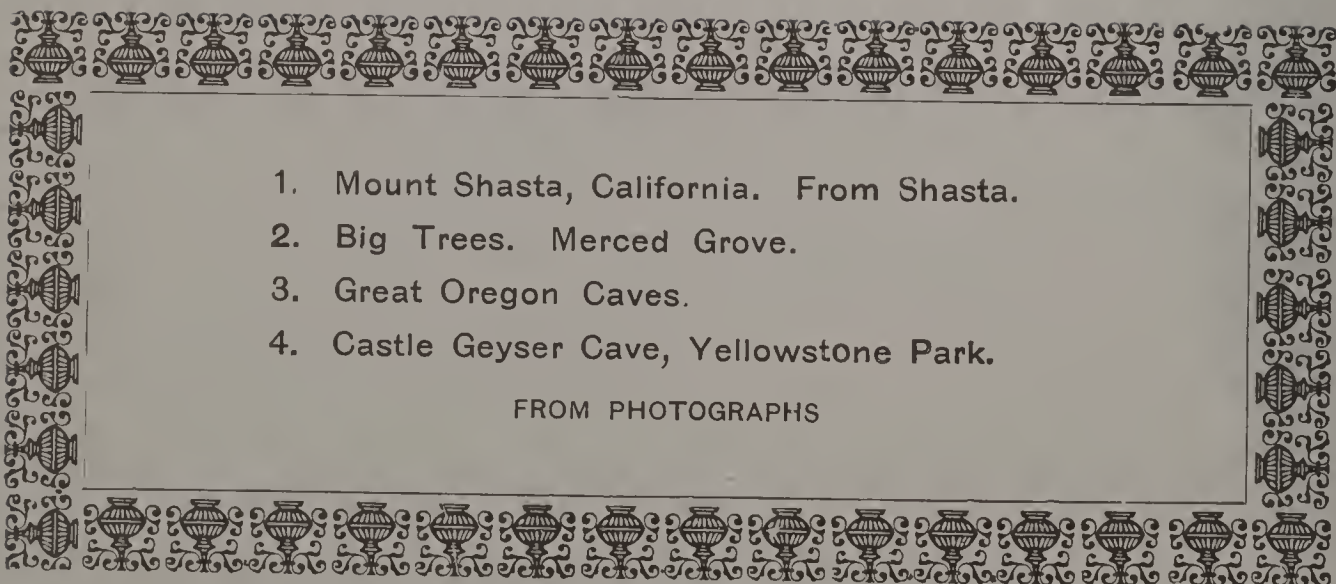
He arose, and walked up to one of the trees, spread his arms around it as far as they would go. Then he moved sidewise, placing his left fingers where his right hand had been. He repeated this again and again, and found that he had to do it twenty times before he could circle the trunk. He looked up and saw that many of the branches were from three to seven feet in diameter; that there were no end of smaller ones that were as big as ordinary trees, and he figured that if all those branches were cut off close to the trunk and set in the ground he would have a good-sized forest of big timber.

Well, when he got back to civilization and sprung this yarn on his fellow-townsmen, they admitted they had heard liars before, but that the very biggest liar they had ever heard was a George Washington compared with Dowd.

As a matter of fact, his stories were much less wonderful than the trees themselves. It is almost impossible to comprehend how impressive these giants are without actually seeing them, but some idea of their size may be had by comparing them with things of everyday life. We have all more or less of an idea of the great height of the Flatiron Building in New York City. If a giant sequoia were transplanted to the corner of Broadway and Fifth Avenue, the roof of the tall building would be in shadow. More than that, if the tallest elm on Manhattan Island were set up on the roof of the "Flatiron" the upper branches of the big tree would shade the elm as well.

General Walteuffel stated some time ago, that if he



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1. Mount Shasta, California. From Shasta.
 2. Big Trees. Merced Grove.
 3. Great Oregon Caves.
 4. Castle Geyser Cave, Yellowstone Park.

FROM PHOTOGRAPHS

could have had one of these big trees to throw across the Pei-ho River upon the arrival of the international army, it would have served as a bridge across which he could have marched the entire army of 30,000 men into Pekin in forty-five minutes.

But it is not their size alone which makes these great trees so impressive; their age is even more remarkable. We are often reminded of the great antiquity of the pyramid of Cheops; yet when the great army of 100,000 men began work on that edifice, 2,000 years before Christ, the great sequoias were already older than the pyramid is to-day; they had battled with the elements for probably at least 4,000 years. They are to-day the very oldest living things on the face of this earth. And Americans should regard them as a priceless heritage, which once taken from them could never be replaced, and they should at any cost guard them forever from those who with axe and saw would in one week destroy the work of 8,000 years.

THE MAMMOTH TREES OF MARIPOSA AND FRESNO.

BY

T. M. HUTCHINGS.

“Go abroad
Upon the paths of Nature, and, when all
Its voices whisper, and its silent things
Are breathing the deep beauty of the world,
Kneel at its simple altar, and the God
Who hath the living waters shall be there.”

—N. P. WILLIS.

FOR several years after the discovery of the mammoth trees of Calaveras county had astonished the world, that group of trees was supposed to be the only one of the kind in existence. But, during the latter part of July or the beginning of August, 1855, Mr. Hogg, a hunter, in the employ of the South Fork Merced

From “Scenes of Wonder and Curiosity.”

Canal Company, while in the pursuit of his calling, saw one or more trees, of the same variety and genus as those of Calaveras, growing on one of the tributaries of Big Creek, and related the fact to Mr. Galen Clark, and other acquaintances. Late in September, or early in October ensuing, Mr. J. E. Clayton, civil engineer, residing in Mariposa, while running a line of survey for Colonel J. C. Fremont, across some of the upper branches of the Fresno River, discovered other trees of the same class, but, like Mr. Hogg, passed on without further examination or exploration.

About the 1st of June, Mr. Milton Mann and Mr. Clark mutually agreed to go out on a hunting excursion in the direction indicated by Mr. Hogg and Mr. Clayton, for the purpose of ascertaining definitely the locality, size, and number of the trees mentioned.

Well mounted, they left Clark's Rancho, and proceeded up the divide between the South Fork of the Merced and Big Creek, in a southeastern course, with the intention of making a circuit of several miles, if not at first successful—this plan being the most suggestive of their rediscovery.

When on the summit of the mountain, about four miles from Clark's, they saw the broad and towering tops of the mammoth trees—since known as the "Mariposa Grove"—and shortly afterward were walking among their immense trunks. A partial examination revealed the fact, that a second grove of trees had been found, that was far more extensive than that of Calaveras, and many of the trees fully as large as those belonging to that world-renowned group.

Early the following spring, Mr. Clark discovered two smaller groves of large trees, of the same class and variety, each not exceeding a quarter of a mile in distance from the other, and about the end of July of the same year, he discovered another large grove upon the headwaters of the Fresno.

Who can picture, in language, or on canvas, all the sublime depths of wonder that flow to the soul in thrilling and intense surprise, when the eye looks upon these great

marvels? Long vistas of forest shades, formed by immense trunks of trees, extending hither and thither: now arched by the overhanging branches of the lofty taxodiums, then by the drooping boughs of the white-blossomed dogwood; while the high, moaning sweep of the pines, and the low whispering swell of the firs, sung awe-inspiring anthems to their great Planter.

The Indians, in years that are past, have, with Vandal hands, set portions of this magnificent forest on fire; so that burnt stumps of trees and blackened underbrush frown upon you from several points. Indeed, many of the largest and noblest looking are badly deformed from this cause. Still, beautiful clumps of from three to ten trees in each, and others standing alone, are numerous, sound, and well formed.

“Passing up the ravine, or basin,” says Mr. J. Lamson, “we came to a large stem, whose top had been stripped of its branches, giving it somewhat the resemblance of an immense spear, and forcibly reminding one of Milton’s description of Satan’s weapon:

“To equal which, the tallest pine
Hewn on Norwegian hills to be the mast
Of some great ammiral, were but a wand.”

Believing this to be far greater than any tree Milton ever dreamed of, and fully equal to the wants of any reasonable Prince of Darkness, in compliment to the poet and his hero, we named it ‘Satan’s Spear.’ Its circumference is seventy-eight feet.

“Several rods to the left of this, is another large trunk, with a dilapidated top, presenting the appearance of a tower, it is called ‘The Giant’s Tower’; seventy feet in circumference. Beyond this, stand two double trees, which have been named ‘The Twin Sisters.’ Still further on, is a tree with a straight and slender body, and a profusion of beautiful foliage; near which frowned a savage-looking monster, with a scarred and knotted trunk, and gnarled and broken branches, bringing to one’s recollection the story of ‘Beauty and the Beast.’ Crossing the ravine near ‘Satan’s Spear,’ there are many fine trees

upon the side and summit of the ridge. One of the finest, whose circumference is sixty feet, and whose top consists of a mass of foliage of exceeding beauty, is called 'The Queen of the Forest.' Above these, stands 'The Artist's Encampment,' seventy-seven feet in circumference, though so large a portion of its trunk has decayed or been burned away to a height of thirty feet, as materially to lessen its dimensions."

As the size of the principal trees was ascertained by Mr. Clark, and Colonel Warren, editor of the *California Farmer*, in which journal it first appeared, and as their measurements doubtless approximated to correctness, we give them below:

"The first tree was 'The Rambler,' and measuring it three and a half feet from the ground, we found it eighty feet in circumference; close at the ground, one hundred and two feet; and, carefully surveyed, two hundred and fifty feet high. Tree No. 2, nearly fifty feet in circumference. No. 3 (at the spring), ninety feet, three and a half feet from the ground; one hundred and two at the ground; and three hundred feet high. Nos. 4 and 5 ('The Sisters') measured eighty-two and eighty-seven feet in circumference, and two hundred and twenty-five feet high. Many of the trees had lost portions of their tops, by the storms that had swept over them.

"The whole number measured, was one hundred and fifty-five, and these comprise but about half the group, which we estimate cover about two to three hundred acres, and lie in a triangular form. Some of the trees first meet your view in the vale of the mountain; thence rise southeasterly and northwesterly, till you find yourself gazing upon the neighboring points, some ten miles from you, whose tops are still covered with their winter snows.

"Some of these were in groups of three, four, and even five, seeming to spring from the seeds of one cone. The groups of trees consisted of many of peculiar beauty and interest. One of those, which measured one hundred feet in circumference, was of exceeding gigantic proportions, and towered up three hundred feet; yet a portion of its

top, where it apparently was ten feet in diameter, had been swept off by storms.

“Near by it stood a smaller tree, that seemed a child to it, yet it measured forty-seven feet in circumference. Not far from it was a group of four splendid trees, two hundred and fifty feet high, which we named the ‘Four Pillars,’ each over fifty feet in circumference. Two gigantic trees, seventy-five and seventy-seven feet in circumference, were named ‘Washington’ and ‘Lafayette’; these were noble trees. Another group we called ‘The Graces,’ from their peculiar beauty. One mighty tree that had fallen by fire and burned out, into which we walked for a long distance, we found to be the abode of the grizzly; there he had made his nest, and it excited the nerves to enter so dark an abode. Yet it was a fitting place for a grizzly. Another tree, measuring eighty feet, and standing aloof, was called the ‘Lone Giant’; it went heavenward some three hundred feet. One monster tree that had fallen and been burned hollow, has been recently tried, by a party of our friends, riding, as they fashionably do, in the saddle, through the tunnel of the tree. These friends rode through this tree, a distance of one hundred and fifty-three feet. The tree had been long fallen, and measured, ere its bark was gone and its sides charred, over one hundred feet in circumference, and probably three hundred and fifty feet in height.

“The mightiest tree that has yet been found, now lies upon the ground, and, fallen as it lies, it is a wonder still; it is charred, and time has stripped it of its heavy bark, and yet across the butt of the tree as it lay upturned, it measured thirty-three feet without its bark; there can be no question that in its vigor, with its bark on, it was forty feet in diameter, or one hundred and twenty feet in circumference. Only about one hundred and fifty feet of the trunk remains, yet the cavity where it fell is still a large hollow beyond the portion burned off; and, upon pacing it, measuring from the root one hundred and twenty paces, and estimating the branches, this tree must have been four hundred feet high. We believe it to be the largest tree yet discovered.”

This grove of mammoth trees consists of about three hundred, more or less. It must not be supposed that these large taxodiums monopolize the one mile by a quarter of a mile of ground over which they are scattered; as some of the tallest, largest, and most graceful of sugar pines and Douglass firs we ever saw, add their beauty of form and foliage to the group, and contribute much to the imposing grandeur of the effect.

Crossing a low ridge to the southwestward of the large grove, is another small one, before alluded to, in which there are many fine trees. We measured one sturdy, gnarled old fellow, which, although badly burned, and the bark almost gone, so that a large portion of its original size was lost, is, nevertheless, still ninety feet in circumference.

An immense trunk lay stretched upon the ground, that measured two hundred and sixty-four feet in length, although a considerable portion of its crown has been burned away.

Leaving the South Grove, we struck across Big Creek and its branches, in a course almost due south, as near as the rugged, rock-bound mountain spurs would permit, in the direction of the Fresno group, some of whose majestic and feathery tops could be seen from the ridge we had left behind.

Apparently, these trees were not more than six miles distant from the Mariposa Grove; but, owing to the trailless course we had to take, down and across the spurs of Big Creek, were not less than ten miles. About six o'clock P.M., we arrived at the foot of some of the mammoth trees, that stood on the ridge, like sentinel guards to the grove. These were from fifty to sixty feet, only, in circumference.

This grove consists of about five hundred trees of the taxodium family, on about as many acres of dense forest land, gently undulating. The two largest we could find measured eighty-one feet each in circumference, well formed, and straight from the ground to the top. The others, equally sound and straight, were from fifty-one feet to seventy-five feet in circumference. The sugar

pinus (*Pinus lambertiana*) were remarkably large; one that was prostrate near our camp measured twenty-nine feet and six inches in circumference, and two hundred and thirty-seven feet in length.

There are no less than ten groves of these remarkable trees (*Sequoia gigantea*) already discovered in California. The Calaveras, containing about one hundred trees; the great South Grove, having one thousand three hundred and eighty; the South Tuolumne grove, thirty-one; one unnamed, on the south side of the dividing ridge between the Tuolumne and Merced rivers, below Crane Flat, forty-two trees; the Mariposa groves numbering three hundred and sixty-five; the Fresno, about five hundred; the San Joaquin (estimated at) seven hundred; the Kings and Waweah River belt of big trees, extending for some ten miles, thought to contain thousands; the North Tule River, and the South Tule River, the trees of which are scattered over several square miles. These last-named groves were discovered by Mr. D'Heureuse, of the State Geological Survey, in 1867.

WONDERS OF PLANT-BREEDING.

BY

LUTHER BURBANK,

THE FAMOUS PLANT-BREEDER OF CALIFORNIA.

ONLY the most limited view of plant-breeding can be given in an ordinary thesis. It would be necessary to extend the subject through many volumes to give even a general view of what has already been demonstrated, and that which the clear light of science has yet to bring forth from the depths is too extensive even for the imagination to grasp, except through a full knowledge of what practical field-work has already accomplished.

The fundamental principles of plant-breeding are

simple, and may be stated in few words; the practical application of these principles demands the highest and most refined efforts of which the mind of man is capable, and no line of mental effort promises more for the elevation, advancement, prosperity, and happiness of the whole human race.

Every plant, animal, and planet occupies its place in the order of Nature by the action of two forces—the inherent constitutional life-force with all its acquired habits, the sum of which is heredity; and the numerous complicated external forces or environment. To guide the interaction of these two forces, both of which are only different expressions of the one eternal force, is, and must be, the sole object of the breeder, whether of plants or animals.

When we look about us on the plants inhabiting the earth with ourselves, and watch any species day by day, we are unable to see any change in some of them. During a lifetime, and in some cases perhaps including the full breadth of human history, no remarkable change seems to have occurred. And yet there is not to-day one plant species which has not undergone great, and to a certain extent constant change.

The life-forces of the plant in endeavoring to harmonize and adapt the action of its acquired tendencies to its surroundings may, through many generations, slowly adapt itself to the necessities of existence, yet these same accrued forces may also produce sudden, and to one not acquainted with its past history most surprising and unaccountable changes of character. The very existence of the higher orders of plants which now inhabit the earth has been secured to them only by their power of adaptation to crossings, for through the variations produced by the combination of numerous tendencies, individuals are produced which are better endowed to meet the prevailing conditions of life. Thus to Nature's persistence in crossing do we owe all that earth now produces in man, animals, or plants; and this magnificently stupendous fact may also be safely carried into the domain of chemistry as well, for what are common air and water but

Nature's earlier efforts in that line, and our nourishing foods but the result of myriad complex chemical affinities of later date?

Natural and artificial crossing and hybridization are among the principal remote causes of nearly all otherwise perplexing or unaccountable sports and strange modifications, and also of many of the now well-established species. Variations, without immediate antecedent crossing, occur always and everywhere from a combination of past crossings and environments, for potential adaptations often exist through generations without becoming actual, and when we fully grasp these facts there is nothing mysterious in the sudden appearance of sports; but still further intelligent crossings produce more immediate results and of great value, not to the plant in its struggle with natural forces, but to man, by conserving and guiding its life-forces to supply him with food, clothing, and innumerable other luxuries and necessities. Plant-life is so common that one rarely stops to think how utterly dependent we are upon the quiet, but magnificently powerful work which they are constantly performing for us.

It was once thought that plants varied within the so-called species but very little, and that true species never varied. We have more lately discovered that no two plants are ever exactly alike, each one having its own individuality, and that new varieties having endowments of priceless value, and even distinct new species, can be produced by the plant-breeder with the same precision that machinery for locomotion and other useful purposes are produced by the mechanic.

The evolution and all the variations of plants are simply the means which they employ in adjusting themselves to external conditions. Each plant strives to adapt itself to environment with as little demand upon its forces as possible and still keep up in the race. The best-endowed species and individuals win the prize, and by variation as well as persistence. The constantly varying external forces to which all life is everywhere subjected demand that the inherent internal force shall always be ready to adapt itself or perish.

The combination and interaction of these innumerable forces embraced in heredity and environment have given us all our bewildering species and varieties, none of which ever did or ever will remain constant, for the inherent life-force must be pliable or outside forces will sooner or later extinguish it. Thus adaptability, as well as perseverance, is one of the prime virtues in plant as in human life.

Plant-breeding is the intelligent application of the forces of the human mind in guiding the inherent life-forces into useful directions by crossing to make perturbations or variations and new combinations of these forces, and by radically changing environments, both of which produce somewhat similar results, thus giving a broader field for selection, which again is simply the persistent application of mental force to guide and fix the perturbed life-forces in the desired channels.

Plant-breeding is in its earliest infancy. Its possibilities, and even its fundamental principles, are understood but by few; in the past it has been mostly dabbling with tremendous forces, which have been only partially appreciated, and it has yet to approach the precision which we expect in the handling of steam or electricity, and, notwithstanding the occasional sneers of the ignorant, these silent forces embodied in plant-life have yet a part to play in the regeneration of the race which by comparison will dwarf into insignificance the services which steam and electricity have so far given. Even unconscious or half-conscious plant-breeding has been one of the greatest forces in the elevation of the race. The chemist, the mechanic have, so to speak, domesticated some of the forces of Nature, but the plant-breeder is now learning to guide even the creative forces into new and useful channels. This knowledge is a most priceless legacy, making clear the way for some of the greatest benefits which man has ever received from any source by the study of Nature.

A general knowledge of the relations and affinities of plants will not be a sufficient equipment for the successful plant-breeder. He must be a skilful botanist and biolo-

gist, and having a definite plan, must be able to correctly estimate the action of the two fundamental forces, inherent and external, which he would guide.

The main object of crossing genera, species, or varieties is to combine various individual tendencies, thus producing a state of perturbation or partial antagonism by which these tendencies are, in later generations, dissociated and recombined in new proportions, which gives the breeder a wider field for selection; but this opens a much more difficult one—the selection and fixing of the desired new types from the mass of heterogeneous tendencies produced, for by crossing bad traits as well as good are always brought forth. The results now secured by the breeder will be in proportion to the accuracy and intensity of selection, and the length of time they are applied. By these means the best of fruits, grains, nuts, and flowers are capable of still further improvements in ways which to the thoughtless often seem unnecessary, irrelevant, or impossible.

When we capture and domesticate the various plants, the life-forces are relieved from many of the hardships of an unprotected wild condition, and have more leisure, so to speak, or, in other words, more surplus force, to be guided by the hand of man under the new environments into all the useful and beautiful new forms which are constantly appearing under cultivation, crossing, and selection. Some plants are very much more pliable than others, as the breeder soon learns. Plants having numerous representatives in various parts of the earth generally possess this adaptability in a much higher degree than the monotypic species, for having been subjected to great variations of soil, climate, and other influences, their continued existence has been secured only by the inherent habits which adaptation demanded, while the monotypic species not being able to fit themselves for their surroundings without a too radically expensive change, have continued to exist only under certain special conditions. Thus two important advantages are secured to the breeder who selects from the genera having numerous species—the advantage of natural pliability, and in

the numerous species to work upon by combination for still further variations.

The plant-breeder before making combinations should with great care select the individual plants which seem best adapted to his purpose, as by this course many years of experiment and much needless expense will be avoided. The differences in the individuals which the plant-breeder has to work upon are sometimes extremely slight. The ordinary unpractised person cannot by any possibility discover the exceedingly minute variations in form, size, color, fragrance, precocity, and a thousand other characters which the practised breeder perceives by a lightning-like glance. The work is not easy, requiring an exceedingly keen perception of minute differences, great practice, and extreme care in treating the organisms operated upon, and even with all the naturally acquired variations added to those secured by scientific crossing and numerous other means the careful accumulation of slight individual differences through many generations is imperative, after which several generations are often, but not always, necessary to thoroughly "fix" the desired type for all practical purposes.

The above applies to annuals, or those plants generally reproduced by seed. The breeder of plants which can be reproduced by division has great advantage, for any valuable individual variation can be multiplied to any extent desired without the extreme care necessary in fixing by linear breeding the one which must be reproduced by seed. But even in breeding perennials the first deviations from the original form are often almost unappreciable to the perception, but by accumulating the most minute differences through many generations the deviation from the original form is often astounding. Thus by careful and intelligent breeding any peculiarity may be made permanent, and valid new species are at times produced by the art of the breeder, and there is no known limit to the improvement of plants by education, breeding, and selection.

The plant-breeder is an explorer into the infinite. He will have "No time to make money," and his castle, the

brain, must be clear and alert in throwing aside fossil ideas and rapidly replacing them with living, throbbing thought followed by action. Then, and not till then, shall he create marvels of beauty and value in new expressions of materialized force, for everything of value must be produced by the intelligent application of the forces of Nature which are always awaiting our commands.

The vast possibilities of plant-breeding can hardly be estimated. It would not be difficult for one man to breed a new rye, wheat, barley, oats, or rice which would produce one grain more to each head, or a corn which would produce an extra kernel to each ear, another potato to each plant, or an apple, plum, orange, or nut to each tree.

What would be the result? In five staples only in the United States alone the inexhaustible forces of Nature would produce annually, without effort and without cost, 5,200,000 extra bushels of corn, 15,000,000 extra bushels of wheat, 20,000,000 extra bushels of oats, 1,500,000 extra bushels of barley, 21,000,000 extra bushels of potatoes.

But these vast possibilities are not alone for one year, or for our own time or race, but are beneficent legacies for every man, woman, and child who shall ever inhabit the earth. And who can estimate the elevating and refining influences and moral value of flowers with all their graceful forms and bewitching shades and combinations of colors and exquisitely varied perfumes? These silent influences are unconsciously felt even by those who do not appreciate them consciously, and thus with better and still better fruits, nuts, grains, and flowers will the earth be transformed, man's thoughts turned from the base, destructive forces into the nobler productive ones which will lift him to higher planes of action toward that happy day when man shall offer his brother man, not bullets and bayonets, but richer grains, better fruits, and fairer flowers.

Cultivation and care may help plants to do better work temporarily, but by breeding, plants may be brought into existence which will do better work always in all

places and for all time. Plants are to be produced which will perform their appointed work better, quicker, and with the utmost precision.

Science sees better grains, nuts, fruits, and vegetables, all in new forms, sizes, colors, and flavors, with more nutrients and less waste, and with every injurious and poisonous quality eliminated, and with power to resist sun, wind, rain, frost, and destructive fungus and insect pests; fruits without stones, seeds, or spines; better fibre, coffee, tea, spice, rubber, oil, paper, and timber trees, and sugar, starch, color, and perfume plants. Every one of these, and ten thousand more, are within the reach of the most ordinary skill of plant-breeding.

Man is slowly learning that he too may guide the same forces which have been through all the ages performing this beneficent work which he sees everywhere above, beneath, and around him in the vast teeming animal and plant life of the world.

These lines were penned among the heights of the Sierras, while resting on the original material from which this planet was made. Thousands of ages have passed, and it still remains unchanged. In it no fossils or any trace of past organic life are ever found, nor could any exist, for the world creative heat was too intense. Among these dizzy heights of rock, ice-cleft, glacier-plowed, and water-worn, we stand face to face with the first and latest pages of world creation, for now we see also tender and beautiful flowers adding grace of form and color to the grisly walls, and far away down the slopes stand the giant trees, oldest of all living things, embracing all of human history; but even their lives are but as a watch-tick since the stars first shone on these barren rocks, before the evolutive forces had so gloriously transfigured the face of our planet home.

THE WORK OF LUTHER BURBANK.

OF the work of Luther Burbank, President David Starr Jordan of Leland Stanford Junior University, says: Years ago in Massachusetts, he crept around in the mud half a day looking for

the lone potato-ball on a plant with which he had been playing. It had been torn off by the foot of a stray cow. People said that he was a fool, not knowing that this one potato-ball was the fruition of years of labor. It was big with the potency of the Burbank potato. Later, when a prosperous nurseryman, he let go all his business to play with scissors and pollen and microscope, planting seeds and grafting bushes, then pulling them up and burning them by the thousand, meanwhile growing poorer every year, for the harder he worked the less his financial returns—then people said again he was a fool. Later, when wonderful blooms, gorgeous roses, vigorous walnuts, and flowers and fruits undreamed of, sprang up at Santa Rosa, people the world over came to see them and him and said, "Burbank is a wizard."

But when men of science, men like De Vries and his associates, came to see Burbank, they knew him for a man of science. A man of science is one who takes knowledge seriously; who, believing in the truth of human experience, trusts his life to it, and has the courage to use it in his business. All the world knows Burbank now, but there are two who found him out earlier than any one else, and who had faith in his work and his future before any one else had realized what he was doing. These two men are Judge Leib of San José and Professor Wickson of the University of California.

To understand Burbank's relation to the science of organic evolution, and to the five factors of evolution—heredity, variation, environment, selection, and isolation, on the inter-relation of which the movements of life depend,—we must first look at Burbank's method. It is simplicity itself. You can all do the same things in your own gardens. First choose the best of the plants you wish to develop. This is selection, the "magician's wand," as Youatt calls it, by which the breeder can summon up any form of animal or plant he may need for his use or his pleasure. Choose the best; destroy the others; Nature will do the rest. Like produces like; that is heredity. But heredity can be helped

along by another element, crossing. Breed the best with the best. Some of the progeny will have the good qualities of both parents, some the bad. If your crosses are wide apart you may get new combinations undreamed of. Select these again. Breed from the best; ruthlessly burn up the rest. A flower is Nature's advertising medium, calling the bees to fertilize her germ cells. There were no showy flowers, flowers with petals, until after there were insects, and to please the insects is the flower's real purpose. You don't want the insects. You must manage the crossing yourself. So snip off the flowers, keep the bees away, and transfer the pollen to the right place with your own dainty fingers. This needs care, skill, patience, science—every virtue demanded by the finest art. And in this art no one has been more skilful than Luther Burbank. Crossing and selection, selection and crossing, this is the whole secret, as simple as any of all the secrets of Nature. It is her method of evolution. Arrange the conditions and Nature will do the rest. But it is one of the finest of all fine arts to arrange these conditions, to bring out the results, results all unseen before, but capable of the exactest forecast.

The commercial value of Burbank's work is great. It can be expressed only in figures far beyond its actual cost. But above all commercial values we must place Burbank's contributions to human knowledge.

Among other things, and I can enumerate but very few, Burbank has shown the plasticity of Nature. Like produces like, but not necessarily that which actually is. Children resemble their parents in this way, that they tend to do like things, to develop in like ways under like conditions. Change these conditions and all results are changed. Make conditions better, and new structures and new powers burst out. The mutations of De Vries, in Burbank's view, are the reflex of new conditions.

Burbank has shown us that there is no limit to selection. Once started, variation can be intensified; heredity follows it, and evolution of new forms can be led on and on as far as a continuous purpose may choose to carry it.

Crossing of varieties of one species, and hybridization

of distinct species are one and the same thing. Most crosses are fertile, and the results of a skilful cross save years of slow progress by selection. Crossing is to horticulture what punting is to football.

Each group of plants behaves in its own way. Each is a law unto itself. For this reason, as no simple, universal law, like the Mendean law, can be used to cover every hypothesis, a thousand seedling walnuts, descended from hybrid parents, differ from each other in a thousand ways—in every way conceivable in which walnuts can differ.

The advance of flowers, fruits, and grains beyond the primitive types is as great as the advance of palaces as compared with wigwams, of steamships as compared with dug-out canoes. In Pliny's time, the pear was a little rough fruit, not larger than an olive. In future time, we may go as far beyond the Bartlett pear as that has advanced over the crab-pear of the age of Pliny. We are now in the infancy of the work of producing domestic races of animals and plants. No one can forecast the possibilities of the future. And no one will do more than Burbank to make them actual.

Professor Hugo de Vries says: His very first contribution to the wealth of the United States was a new potato, which now bears his name. According to an official statement of the United States Department of Agriculture at Washington, made a few years ago, this Burbank potato is adding to the agricultural productivity of the country an annual amount of \$17,000,000. To convey an idea of the enormous number of Burbank potatoes, some one has calculated that if all the tubers produced in one year were arranged in a row, touching one another, the line would be thrice the distance between the earth and the moon.

Potatoes, however, are not his chief line of work. Neither do the grains nor does the corn attract his attention. They have been improved by others, and are almost everywhere the object of much work and care in this direction. Among fruit trees, on the other hand, many

valuable species have hardly been given any endeavors to improve them in the same way. Apples and pears, of course, have to be excepted, but plums and many of the smaller kinds, such as brambles, have simply been left to themselves. The old types are cultivated everywhere, and the question, whether by the ordinary methods of hybridizing and selection, better and more yielding varieties could be won, has hardly ever been proposed.

Why should this be so? Simply on account of the idea that trees want so many years before the seedling may be judged by its fruits, and that selection is a slow process, requiring a large number of generations to produce remunerating results. The lifetime of one man would not suffice to gain any definite progress.

This, however, is not Burbank's principle. Try everything is his prescript; it holds good as well for living organisms as in the realm of electricity. He only adds: Try it on the largest possible scale, bringing together from all continents and from all countries all the forms that might usefully be combined with the old types. When plums are to be ameliorated no species of the large genus should be left out of consideration. Types from foreign lands, or rare sorts, or long forgotten cultivated varieties may conceal characters that will prove to be the sources of desired ameliorations, or even, as in the case of the stoneless prune, bring wonders which nobody could expect.

His method is simplicity itself. Every one can do the same things in his garden. Selection is the choice of the best and the destruction of the others; nature does the rest. But you have to arrange the conditions, and this is one of the finest of all arts. It is the work of the genius, and the heaping up of unexpected results is a favor, which nature throws only in the lap of very few men. The commercial as well as the scientific value of Burbank's work is great, and can hardly be overestimated.

WONDERS OF ANIMAL DEVELOPMENT.

BY

PROFESSOR HENRY FAIRFIELD OSBORN,

DA COSTA PROFESSOR OF ZOOLOGY IN COLUMBIA UNIVERSITY, 2ND VICE-PRESIDENT AND CURATOR OF VERTEBRATE PALÆONTOLOGY IN THE AMERICAN MUSEUM OF NATURAL HISTORY, GEOLOGIST AND PALÆONTOLOGIST OF THE UNITED STATES GEOLOGICAL SURVEY.

THE veneration of age sentiment which should, and I believe actually does, appeal to the American people when clearly presented to them even more strongly than the commercial sentiment, is roused in equal strength by an intelligent appreciation of the race longevity of the larger animals which our ancestors found here in profusion, and of which but a comparatively small number still survive. To the unthinking man a bison, a wapiti, a deer, a pronghorn antelope, is a matter of hide and meat; to the real nature lover, the true sportsman, the scientific student, each of these types is a subject of intense admiration. From the mechanical standpoint they represent an architecture more elaborate than that of Westminster Abbey, and a history beside which human history is as of yesterday.

These animals were not made in a day, nor in a thousand years, nor in a million years. As said the first Greek philosopher, Empedocles, who 560 B.C. adumbrated the "survival of the fittest" theory of Darwin, they are the result of ceaseless trials of nature. While the Sequoia was first emerging from the Carboniferous, or Coal Period, the reptile-like ancestors of these mammals, covered with scales and of egg-laying habits, were crawling about and giving not the most remote prophecy of their potential transformation through ten million years into the superb fauna of the northern hemisphere.

The descendants of these reptiles were transformed into mammals. If we had had the opportunity of studying the early mammals of the Rocky Mountain region with a full appreciation of the possibilities of evolution, we should have perceived that they were essentially of the same stock and ancestral to our modern types. There

were little camels scarcely more than twelve inches high, little taller than cotton-tail rabbits and smaller than the jackass rabbits; horses fifteen inches high, scarcely larger than, and very similar in build to, the little English coursing hound known as the whippet; it is not improbable that we shall find the miniature deer; there certainly existed ancestral wolves and foxes of similarly small proportions. You have all read your Darwin carefully enough to know that neither camels, horses, nor deer would have evolved as they did except for the stimulus given to their limb and speed development by the contemporaneous evolution of their enemies in the dog family.

A million and a half years later these same animals had attained a very considerable size; the western country had become transformed by the elevation of the plateaux into dry, grass-bearing uplands, where both horses and deer of peculiarly American types were grazing. We have recently secured some fresh light on the evolution of the American deer. Besides the *Palæomeryx*, which may be related to the true American deer *Odocoileus*, we have found the complete skeleton of a small animal named *Merycodus*, nineteen inches high, possessed of a complete set of delicate antlers with the characteristic burr at the base indicating the annual shedding of the horn, and a general structure of skeleton which suggests our so-called pronghorn antelope, *Antilocapra*, rather than our true American deer, *Odocoileus*. This was in all probability a distinctively American type. Its remains have been found in eastern Colorado in the geological age known as Middle Miocene, which is estimated (*sub rosâ*, like all our other geological estimates), at about a million and a half years of age. Our first thought as we study this small, strikingly graceful animal, is wonder that such a high degree of specialization and perfection was reached at so early a period; our second thought is the reverence for age sentiment.

The conditions of environment were different from what they were before or what they are now. These animals flourished during the period in which western

America must have closely resembled the eastern and central portions of Africa at the present time.

This inference is drawn from the fact that the predominant fauna of America in the Middle and Upper Miocene Age and in the Pliocene was closely analogous to the still extant fauna of Africa. It is true we had no real antelopes in this country, in fact none of the bovines, and no giraffes; but there was a camel which my colleague Matthew has surnamed the "giraffe camel," extraordinarily similar to the giraffe. There were no hippopotami, no hyraces. All these peculiarly African animals, of African origin, I believe, found their way into Europe at least as far as the Sivalik Hills of India, but never across the Bering Sea Isthmus. The only truly African animal which reached America, and which flourished here in an extraordinary manner, was the elephant, or rather the mastodon, if we speak of the elephant in its Miocene stage of evolution. However, the resemblance between America and Africa is abundantly demonstrated by the presence of great herds of horses, of rhinoceroses, both long and short limbed, of camels in great variety, including the giraffe-like type which was capable of browsing on the higher branches of trees, of small elephants, and of deer, which in adaptation to somewhat arid conditions imitated the antelopes in general structure.

The Glacial Period eliminated half of this fauna, whereas the equatorial latitude of the fauna in Africa saved that fauna from the attack of the Glacial Period, which was so fatally destructive to the animals in the more northerly latitudes of America. The glaciers or at least the very low temperature of the period eliminated especially all the African aspects of our fauna. This destructive agency was almost as baneful and effective as the mythical Noah's flood. When it passed off, there survived comparatively few indigenous North American animals, but the country was repopulated from the entire northern hemisphere, so that the magnificent wild animals which our ancestors found here were partly North American and partly Eurasiatic in origin.

Our animal fortune seemed to us so enormous that it never could be spent. Like a young rake coming into a very large inheritance, we attacked this noble fauna with characteristic American improvidence, and with a rapidity compared with which the Glacial advance was eternally slow; the East went first, and in fifty years we have brought about an elimination in the West which promises to be even more radical than that effected by the ice. We are now beginning to see the end of the North American fauna; and if we do not move promptly, it will become a matter of history and of museums.

WONDERS OF ATOMS

BY

JOHN TYNDALL, LL.D., F.R.S.

TO use the language of an American poet, the atoms “march in tune,” moving to the music of law, which thus renders the commonest substance in nature a miracle of beauty. It is the function of science not, as some think, to divest this universe of its wonder and its mystery, but to point out the wonder and the mystery of common things (such as) those fern-like forms which on a frosty morning overspread your window panes. . . . Over a piece of perfectly clean glass I pour a little water in which a crystal has been dissolved. A film of the solution clings to the glass, and this film will now be shown to crystallize before your eyes. By means of a microscope and a lamp, an image of the plate of glass is thrown upon the screen. . . . A dozen square feet of surface are now covered by these beautiful forms. With another solution we obtain crystalline spears, feathered right and left by other spears. From distant nuclei in the middle of the field of view, the spears shoot with magical rapidity in all directions. The film of water on a window pane on a frosty morning exhibits effects quite as wonderful as these. Latent in this formless solution, latent in every drop of water, lies this marvelous structural power, which only requires the withdrawal of opposing force to bring it into action.

Our next experiment you will probably consider more startling even than these. The clear liquid now held before you is a solution of nitrate of silver, a compound of silver and nitric acid. When an electric current is sent through this liquid, the silver is severed from the acid. . . . Let us close the circuit and send the current through the liquid. From one of the wires a beautiful silver tree commences immediately to sprout. Branches of the metal are thrown out and umbrageous foliage loads the branches. You have here a growth apparently as

wonderful as that of any vegetable perfected before your eyes. . . . These experiments show that the common matter of our earth,—“brute matter,” as Doctor Young is pleased to call it,—when its atoms and molecules are permitted to bring their forces into free play, arranges itself under the operation of these forces into forms which rival in beauty those of the vegetable world. And what is the vegetable world itself but the complex play of these molecular forces?

Trees grow and so do men and horses, and here we have new power incessantly introduced upon the earth. But its source is the sun. For he it is who separates the carbon from the oxygen of the carbonic acid and thus enables them to recombine. Whether they recombine in the furnace of the steam engine or the animal body, the origin of the power they produce is the same. In this sense, we are all “souls of fire and children of the sun.” But, as remarked by Helmholtz, we must be content to share our celestial pedigree with the meanest living things.

From “Fragments of Science,” American Edition, D. Appleton & Co.

WONDERS OF EARTH'S VAST OCEAN.

BY

AGNES GIBERNE.

"Thou great strong sea."—AUBERON HERBERT.

"Drop by drop He counts
The flood of Ocean as it mounts."—C. ROSSETTI.

IN these days we know the Ocean as one vast whole. Not like our early forefathers, standing on the brink, to gaze with awe-stricken eyes into mysterious distances, and to speculate upon the unknown.

Minor oceans do exist, certainly. We have the Atlantic, North and South; the Pacific, North and South; the Arctic, the Antarctic, and the Indian. Yet for us there is but one great world-wide OCEAN, encircling the Earth, every part being in connection with every other part.

A drop of water, which to-day floats in southern seas, may months or years hence, have found its way by currents into the far north. A speck of ice, at this moment fast in the rigid embrace of polar berg or floe, may, months or years hence, be washing to and fro in tropical waters.

A much greater area of water than of land is found upon the Earth's surface. So vast is the amount of the former that, if the whole had to be put into separate vessels, each vessel being one cubic mile in size, the number of such vessels required would amount to no less than *three hundred and thirty-five millions*. This very large order speaks for itself.

The outer Crust of our Earth, taking land and sea together, may be divided into three distinct parts. Like most such divisions in Nature, the one is often found to glide by gentle stages into another.

NOTE.—Properly speaking, as will be seen from this article, there is but one ocean, or sea, all the salt water on the globe, with a few trifling exceptions, being more or less in complete communication with each other.

The area of the ocean is about 155,000,000 square miles, or nearly three-fourths of the whole surface of the earth. This space is distributed (in square miles), among the principal seas as follows: Arctic, 5,000,000; Southern, 10,000,000; Indian, 20,000,000; Atlantic, 40,000,000; Pacific, 80,000,000.

From "The Romance of the Mighty Deep." London and Philadelphia.

We have, first, Land, rising above the sea-level, and consisting of plains, undulations, hills, mountains. It covers altogether less than one-third of the Earth's surface, and it is called THE CONTINENTAL AREA, though Islands as well as Continents belong to it.

We have, secondly, the Ocean-floor under deeper parts of the Ocean; that which lies beyond a depth of about two miles. This division has been described as the "great submerged plain," and it comprises about one-half of the Earth's surface. It is known as THE ABYSMAL AREA.

We have, thirdly, a middle region, which may be spoken of as a kind of borderland under the sea, connecting the dry land with the greater ocean-depths. It amounts to about one-sixth of the Earth's surface, and it has been named THE TRANSITIONAL AREA.

By "connecting" the two, I do not mean that it must always be between the two. It does very generally so lie, but there are exceptions. Some deeper portions of the sea are close to land, and some parts of the Transitional Area are found far out at sea.

The meaning of the word "Continental" needs no explanation; and the very word "Abysmal" carries its own sense.

A curious law seems to have governed the grouping of land and water. Putting aside innumerable small islands, scattered about, we find that the great mass of land clusters towards and round the north pole, with a water-and-ice-filled hollow for its centre. While, on the contrary, the greater mass of water may be said to cluster towards and round the south pole, with—so far as we can conjecture—a large extent of land for its centre. The conditions of north and south thus seem to be exactly reversed.

Not long ago it was believed that the ocean's floor might be a fairly close imitation of that which we see on land. The difficulties, however, have been found to be greater than was expected. Perhaps it is not surprising, when one thinks of the immense levelling power of water.

That must be a firm make of rock which can permanently resist the effect of sea waves breaking upon or near the shore. And even deeper down, where waves are not and currents may be slow, some movement must still exist, since the ocean is nowhere quite stagnant. Such movements, no matter how gentle, would tend to shift all loose and soft substances.

The ocean-bed is held to be generally flat, though with gradual slopes here and there, leading up or down to higher or lower levels. Many submarine mountains rear their heads, sometimes near the surface, sometimes above it. In places high mountain-ridges run for a long distance below the sea, with profound depths on either side; and these again often show their peaks, forming groups of islands.

Broad reaches of the ocean are between two and three miles deep, and here and there spots are found where the sounding-line goes sheer down three miles, four miles, five miles, even six miles, before touching bottom. These greater depressions have been named "Deeps."

At least fifteen of them are known in the Atlantic, and twenty-four in the Pacific; many of the latter lying close to islands. Some are long in shape, some short; some are broad, some narrow. One of the most profound, and almost the only one known to exceed five thousand fathoms, lies towards the southeast of the Friendly Islands. A depth there has been found five hundred and thirty feet beyond five geographical miles; and five geographical miles are equal to almost six of our common miles.

For a good while the notion was entertained that, probably, the loftiest mountain-peak on land, and the deepest depth in the ocean, would about match one another, reckoned from the sea-level. But this particular "deep" in the Pacific sinks two thousand feet lower than the topmost peak on Earth rises. Mount Everest, in the Himalayas, is twenty-nine thousand feet high; and this ocean-depth is about thirty-one thousand feet deep. Only one other equal to it has yet been discovered.*

* It is fair to add that doubts have been expressed as to the precise height of Mount Everest. This mountain *may* yet prove to equal in altitude the depth of Ocean's greater deeps.

No abyss divides England from France. The "silver streak," though sufficient for purposes of defence, is comparatively shallow. All West Europe, indeed, rises from a plateau, reaching from Norway into the Atlantic, on no part of which is the water more than six hundred feet in depth. The "transitional area" in this case makes a true stepping-stone or ledge between dry land and ocean's abyss.

But another great plateau in the Atlantic, which may be called the "backbone" of that Ocean, is far from land, running roughly from north to south. It follows the outlines of the eastern and western shores, and rises often to within a mile and a half of the surface. On either side of the "backbone," which seems to be largely volcanic, is a deep trough, lying north and south, and varying in depth from two to four miles. This plateau unites Europe with Iceland; and it forms a bond between the islands of the Azores, Ascension, and Tristan D'-Acunha.

If by any means the whole ocean-surface could be lowered six hundred feet, remarkable results would be seen.

At once the British Isles would cease to be Islands. They would become a part of the Continent of Europe, joined thereto by dry land. The Hebrides, the Orkneys, the Shetlands, would share in this change. The Continents of Asia and North America would be united at the Behring Straits; Ceylon would find itself a part of India; Papua and Tasmania would be one with Australia; and all places hitherto on the coasts of different countries would find themselves six hundred feet above the sea.

Such a change in the position of the British Isles, transforming them into a Continental Country, would mean far-reaching consequences to the English as a People. One such consequence may be briefly given in the words of a recent newspaper article: "Dry up the Atlantic to the 100-fathom line, and in six months the English would bear the load of a Conscription as cheerfully and more efficiently than any nation in Europe."

Suppose that another great fall in the ocean-surface could follow. Not this time to six hundred feet, but to

three thousand feet, below its present level. The resulting alterations would be still more sweeping. Not only Iceland and the Färoe Islands, but Greenland also—and not only Greenland, but the Continent of North America itself—would become one with the Continent of Europe, no longer cut off from the Old World.

A word as to measurements. Two kinds of “miles” have been mentioned. There is the ordinary “Statute mile,” used in common conversation, which is 880 fathoms, or 1,760 yards, in length. There is also the “Geographical” or “Nautical” mile—the “knot” of our Navy—which is 1,013 fathoms or 2,026 yards in length.

The difference between the two is not far from one-eighth of a statute mile. Roughly, seven miles are equal to six knots. A fathom is six feet or two yards.

Things are what they are in this world very largely because of the pull of opposing forces, and among such forces not one is more universal than that of Gravity. Many causes beside Weight have their share in making our Earth what it is; but if Weight were banished from our midst, the Earth as we know it would exist no longer.

The only way to get rid of weight would be by getting rid of Gravity. And since no force in Nature acts more steadily and incessantly than this, we are no more likely to get rid of it than we are to get rid of the world itself.

Gravity, or Gravitation, or Attraction—it is known by all these names. Sometimes it is called a Law; sometimes a Force. Neither term may be counted amiss. No law is worth anything without a sufficient force to back it up; and no force is worth anything unless it acts according to law. But we might almost as reasonably call this behavior of things “an Obedience” as “a Law.”

Each particle of each substance draws and is drawn by each other particle of every substance. And each body in the Universe, from a grain of sand to a sun, draws and is drawn by each other body, whether far or near. All these drawings are in obedience to that mysterious something—that force, or power, or influence—which has been named Attraction or Gravitation. So much we know; and beyond it we know very little as to the nature

of the said "Attraction"; but we find that the outcome of it is Weight.

By means of weight, the sun, the moon, the planets, yes, and even the countless multitudes of stars, are kept in their paths; in each case the inward pulling being counterbalanced by the impetus and outward pulling of a rapid rush. By means of weight, houses, rocks, stones, rest firmly on the earth; by means of weight, the atmosphere is bound to the earth, the Ocean to its bed. Had sea-water no weight it might be scattered as fine water-dust through Space.

A larger and heavier Earth would bind down the ocean yet more strongly, while a smaller and lighter Earth would have a weaker grip. Easily as the sea is now stirred by every passing breeze, an ocean such as ours on a little world like the Moon or Mercury would be more rapidly agitated. The waves would leap higher with less cause.

So the Ocean, like the Land, is subject to law, knowing neither repose nor action except in obedience to Nature's forces.

When ocean-waters lie still as a mill-pond, they do so through an exact poise of contending powers. When waves rush high and currents pour strongly, each movement is still in strict obedience to governing forces, which are themselves governed by law. Each movement is due to a long series of past movements; and each in turn helps to bring about a long series of future movements. There are no breaks in the chain. Every effect is also a cause.

Currents here and drifts there; breezes here and hurricanes there; all these disturb the calm of the sea. Only for a brief spell, in one part or another, is the pull of opposing forces so far balanced that the water can lie still. And at most the stillness is comparative. Even in a so-called "dead calm" gentle heavings to and fro will be found. Absolute placidity in the ocean is a thing unknown.

Even when the waters are at their stillest they are always being drawn steadily towards Earth's centre. A

perfectly level ocean would mean each portion of its surface being equally distant from that centre. The ocean ever strives after this ideal, but never attains to it; yet, century after century that aim is pursued, with a perseverance which might afford a lesson to ourselves.

Despite all this change and restlessness, we talk of the ocean having a "level" surface. We picture it to our minds as being in outer shape the same as that of the Earth—a sphere. But this is not strictly true to fact.

If we could look upon the Earth, with large far-seeing eyes, from a few thousands of miles off, we should find curious irregularities in the watery outline. Instead of showing all round a smooth surface, the ocean would be found to rise here and sink there, to be in one part higher, in another part lower. A man roving over the ocean, all about the Earth would have in places to ascend undulations like hills, almost high enough sometimes to be called mountains, in other parts to descend declivities.

Most of us have noticed in a cup filled with water, that the water-surface is not perfectly flat. Close to the sides of the cup may be noticed a distinct rise. This too is seen in a tumbler, and in a basin, and very markedly in a slender glass-tube. The sides of the basin, of the tumbler, or of the glass tube, attract the water, drawing it slightly upward.

With the ocean the very same thing is seen. If high land borders on deep water, the extra attraction of mountain-masses will act just as the sides of a cup or tumbler will act. They draw upward the water of the ocean to a higher level. When I say that this is "seen," I do not mean that any careless looker-on will be aware of the fact. It has to be discovered by careful measurement.

In some cases a marked difference has been found. The enormous masses of the Himalayas are supposed to exert a powerful drawing upon the nearer parts of the sea; and at the delta of the Indus, perhaps partly in consequence of it, the ocean level is three hundred feet higher than on the coast of Ceylon.

Besides land attraction, winds have an extraordinary power to heap up waters in one place more than in an-

other. To some slight extent this may be seen upon English shores, when a strong gale happens to blow landward at high tide. On such occasions the waters often rise far beyond their usual mark.

Those Phœnicians who knew an eastern ocean with tides, and a Mediterranean Sea without tides, must have been perplexed to find a western ocean which corresponded with the eastern in its ebb and flow.

We all know for ourselves in these later days, how the tides rise and fall around our coast, twice in twenty-four hours. Each high-water is twelve hours and twenty-five minutes later than the last; so each succeeding day sees a difference of fifty minutes in the time of high or of low tide.

To a very large extent Tides are due to the attractive power of the moon. They are due also to the sun, but in a much less degree, which at first sight seems singular, since the attraction of the sun, by reason of its greater size, far exceeds that of the moon. From the fact, however, that the powerful drawing of the sun comes from an immense distance, it follows that it has much less effect than the small attraction of the moon, which comes from very near at hand.

Her influence over our earth is exerted far more strongly with respect to those ocean-waters lying just under herself, and far less with respect to those waters on the farther side of the globe. The effect of these different pullings is to raise a double wave or swell,—one on the surface of the ocean just below the moon, and one on the opposite side of the earth. The waves mean high tides; and low tides occur at places halfway between them.

Were the whole Earth covered by one continuous sheet of water, these tidal waves would travel round and round the globe, in a fashion easy and pleasant for students of the subject. Unfortunately for the said students, their motions are very complicated. In the northern hemisphere, where land is abundant, the tidal waves are greatly interfered with by continents and islands. Often the most that each can do, as it sweeps along, is to send

side-waves and currents journeying northward into channels and bays, estuaries and lesser seas.

Through the open ocean the tidal wave has no great height. Probably in central regions of the Pacific it rises only some three or four feet above the usual sea-level. But when the flow enters narrowing bays and channels, a very different result is seen; and the waters are often piled up in a wonderful manner,—as in the Bristol Channel, where the level at high tide is sometimes nearly forty feet above that at low tide.

A marked contrast to this is seen in the Mediterranean. There, as already said, practically no tides exist. The rise and fall amount at most to only a few inches. Instead of a wide entrance and a narrowing estuary, we have just the opposite—a narrow entrance and a widening sea beyond. Connection with the outside ocean is too restricted to admit of any full flow of the tidal wave.

Solar tides, or tides brought about by the sun's attraction, are much the same in cause and effect as lunar tides, only far smaller in degree. When Sun and Moon happen to be on the same side of the Earth, or on different sides but in the same line, so that their combined pull is exerted in one direction, we have Spring Tides. These are always at the time of New Moon and Full Moon. Sun and Moon then work together, each helping the other in a common aim; and the ocean-waters rise higher and sink lower than at other times.

When Sun and Moon are so placed with regard to the Earth, that they exercise their pull in a cross direction, Neap Tides result,—that is tides which have small ebb and flow. In this case the sun hinders instead of helping the moon, and the moon does the same for the sun, each tending to counteract the work of the other.

Connected with and partly caused by the rise of the tide is the curious phenomenon known as a "Bore"—a single high wave, moving onward like a wall of water, with great rapidity and a roaring noise. More usually this belongs to a river, and thus it has not much connection with the subject of the ocean; but it is also sometimes seen in sharply narrowing estuaries or ocean inlets.

To the inhabitants of a flat and unprotected country, bordering on river or estuary, the bore is often a thing of terror, for its advent is uncertain and abrupt, and in its upward rush it sweeps everything before it. The entering of such a wave into the Severn is an almost daily event, and it reaches often a height of many feet. Bores are usual, too, in the River St. Lawrence, in the Hoogly, in an estuary of the Bay of Fundy, and in other places innumerable; and they vary in height from two or three feet to over twelve feet. The effect of such a wall of water as this, deluging low lands, carrying away trees and houses and living creatures, may be easily imagined.

Through ages of the world's history, man knew nothing of the Ocean beyond its surface.

He could sail on the sea; he could bathe in the shallow waters near land. If a good swimmer, he might go farther out, and might even dive for one or two minutes out of sight. In more recent times, with the help of a diving-bell, he could descend thirty or forty feet; and in a diving-dress he might even, if experienced, get from one to two hundred feet down.

But that was all. Of the vast depths beyond he was sublimely ignorant. He did not so much as know of their existence. Until the late scientific expedition made in the vessel *Challenger*, the great world of the Under-Ocean was swathed in mystery.

Nothing is known of it now by direct personal observation. No living man may penetrate those depths. The only mode in which we can learn what is, what lives, what happens there, is by means of "soundings," by sending down and drawing up specially prepared instruments, the reading of which gives us information about that Under-world.

Soundings made in earlier times did little more than tell navigators how deep the sea thereabout might be. Such instruments as were then used could neither work beyond a limited depth, nor say their say with accuracy.

Of late years immense improvements have taken place, both in the make of the machines employed, and in the methods of working them. Past soundings were few

and unsystematic; whereas now they are many and by rule. Thermometers have been made which bring up from the bottom of the sea reports of the prevailing heat or cold, moving unaffected through warm or cold layers between. Specimens of the materials which lie on the ocean-floor have been brought to light, and analyzed. Living creatures in great numbers have been hauled from their own domains, examined and classified.

All this means progress. And though, no doubt, fifty or a hundred years hence, that which we now know will be looked upon as the barest A B C of the science, still our knowledge is growing year by year. The Under-Ocean is no longer a vague fairy-land of possible mermaids, or a waste region of death.

A region of death in one sense it is and must be. All living creatures that die in the sea, unless devoured by other creatures, sink to the bottom, there to find a tomb. Covered at first by a vast winding-sheet of water, they may be slowly buried under the shifting mud and sand. But in this sense the whole Crust of Earth may be called one vast sepulchre, wherein all animals that die are entombed.

People are slow to realize how modern is our knowledge of ocean-depths. About three hundred years ago a famous navigator made the first sounding which went below two hundred fathoms—that is, about one hundred feet deeper than the height of Beachy Head from the shore. He at once decided that, by a happy chance, he had alighted upon the uttermost depth in the ocean.

To him it was an awe-inspiring profundity. Yet, when viewed beside such abysses as have been recently discovered, depths of five and six miles, his little “deep” was as a saucer beside a lake.

It is not easy to picture to ourselves the changeless calm of those abysses—those five or six miles of underwater, with nothing from sea-level to sea-floor to break the dead monotony.

Throughout such regions storms, no matter how terrible, have no power. Winds cannot reach them. When Ocean's surface is lashed by a hurricane into wild com-

motion, that commotion is superficial. It means a furious stirring and flurry of upper layers; and it means no more.

If at the height of some fierce tornado, a sailor could leave his tossing straining ship, and could dive far into the sea, keeping breath and sense and life, he would soon quit the turmoil, and would find himself in a scene of deep repose. Strange to say, the idea of submarine ships actually doing this has been tested, as one of the new projects in the beginning of the Twentieth Century.

Wave-motion does not descend much below the surface. It is believed that the depth of water affected by a wave is usually about equal to the space which divides crest from crest. So, if we are looking at little ripples, flowing one after another, with crests perhaps one foot apart, we may suppose that the water is disturbed by those ripples to a depth of about one foot. Or, if we are watching larger waves, with crests twenty feet apart, we may suppose the disturbance to reach down to a depth of some twenty feet. And if our gaze is fixed on dignified Atlantic rollers, with crests six or eight hundred feet apart, we may suppose that the sea is affected to a depth of six or eight hundred feet—less and less affected the deeper we go down.

Six or eight hundred feet, compared with six miles, are hardly more than a man's skin compared with his body. And beyond the shallow depths where wind and wave have sway, we come to a region of profound calm.

This repose does not mean stagnation. Ocean's waters are ever on the move, travelling this way and that way. Currents exist far below, as well as at the surface; but they are generally slow and placid, not rough and hurrying. Old Ocean's excitability lies all outside. Superficially he is soon upset; but deep down he is composed.

A great deal of discussion has taken place as to possibilities of Light in those depths. Are they black with midnight darkness? or do faint glimmers of daylight creep through?

Ocean-water, like other water, is transparent. Any,

substance is transparent, when thin enough,—even gold. A very thin film of water is not, however, needed for transparency. Many feet, even many yards, may be seen through, if clear and pure. Few of us have not, at one time or another, looked down from a boat, to see golden sand, variegated pebbles, small fishes swimming about at a considerable depth.

Thus with water, as with denser materials, transparency is merely a question of thickness. As the thickness increases, more and more rays of sunlight are taken captive, and the water becomes less and less translucent, till at length, if we could get deep enough, we should find ourselves to be surrounded with blackness.

Another feature of ocean-depths is that of immense pressure.

We bear a certain degree of it in that other and lighter ocean—the Atmosphere. A man of medium size has upon his body about thirty thousand pounds' weight, or some fifteen pounds to the square inch. But this is nothing to what he would have to endure down in ocean-waters. At a depth of one mile, an extra ton would be piled upon each square inch of his body; two miles down, would mean two extra tons on each square inch; three miles down, three extra tons; and so on. The load would soon become intolerable.

For many years scientists maintained that in such depths no life could exist, since no bodies could withstand the awful pressure. Yet we now know that frail jelly-fish, fragile shell-inhabitants, do withstand it, flourishing there by myriads.

Perhaps the fact was somewhat overlooked, that the pressure upon a living creature is not only inwards from without, but also is outwards from within. This is true of ourselves in the ocean of air, breathing air. It is true of creatures in the ocean of water, breathing water.

Much less than the weight of thirty thousand pounds might crush a man flat, were it not for the resisting pressure from within. If for one instant he could empty his body of all inner air and liquids, and could so harden his skin that no air should squeeze through its pores, he

would be pressed as flat as a pancake by the surrounding atmosphere.

A story has been told, illustrative of this. Once upon a time a clever fellow started an original idea. He proposed to make a balloon, which should mount skywards, not from being full of hydrogen gas, but from being emptied of air. Being then lighter than the atmosphere, it would, he said, of course rise.

So far as the reasoning went, it was faultless. It only did not go far enough.

The balloon being made, he named a day for its ascent, and asked many friends to witness his triumph. At the last moment, all air was withdrawn; and everybody waited in expectation, hoping to see the novel balloon skim lightly above their heads.

But the inventor, while using strong materials, had failed to make full allowance for the tremendous pressure of the air, when counteractive pressure from within should have been done away with. As the air was drawn out, the sides of the balloon collapsed, being crushed together as an empty egg-shell may be smashed in a boy's hand. Instead of soaring gaily upward, the would-be aëronaut stood on earth, scanning with disappointed eyes a flattened and useless shell.

A diver going down into the sea has a much increased weight upon his body; but he does not suffer from it to a serious extent, provided that he is not raised or lowered too fast. Much depends upon this. Both men and beasts can endure a good deal of alteration in the degree of pressure, whether from air or from water; but they cannot bear very abrupt changes. Hearts and lungs need time for growing accustomed to a fresh condition. In early days of diving this was not understood, and some divers lost their lives through being too hurriedly hauled up.

The same has been noticed in animals brought quickly from great depths. They have been constantly found in the net or trawl, dying or dead, their bodies swollen and even bursting from the lessening of pressure. It was natural that at first the belief should arise of Life being

in those parts impossible. Now we know that animals die in the act of being drawn up, and that they live and flourish in profound depths, unaffected by the vast load of water.

The weight that a man can endure is not to be compared with what fragile sea-creatures thrive under. Beyond a depth of some two hundred feet or more, the pressure becomes too great for any human beings; yet animals are found at depths of three or four miles. But the fact that man breathes air, and that animals in the sea breathe, in a sense, water, makes an enormous difference in their power to resist pressure.

One might suppose that the terrific weight of miles of water would squeeze lower layers to a smaller bulk. Water is, however, very difficult to compress; unlike air.

At the bottom of the sea, four or five miles deep, the weight is said to be equal to about four tons upon the square inch. If this tremendous load were pressing upon a mass of air, eleven thousand cubic feet in quantity, the whole would be crushed together into only twenty-two cubic feet. But the same weight pressing upon the same quantity of sea-water, would merely reduce its size to ten thousand cubic feet. So there is not much difference between the make of sea-water near the surface and sea-water at a great depth.

Not only are ocean's depths calm and free from storms; not only are they black with midnight darkness; not only are they heavy with the weight of miles of water overhead; but also for the most part they are cold.

Changes from season to season, like changes of weather, are superficial. At a depth of about six hundred feet, Seasons have ceased to be. There, summer and winter, autumn and spring, exist no longer. The dead level of calm and darkness is also a dead level of uniform weather and unalterable climate. Where changes of cold and heat do come about, they are very uncertain, and usually they are due to other causes than those which bring about the succession of seasons upon Earth.

Many remarkable facts have lately come to light with respect to Ocean's temperatures. In far northern and

far southern regions, near the two poles, the whole sea is very cold. One might expect the converse of this in tropical regions—a whole sea intensely warm. But this we do not find. The shallower parts—those included in the hundred-fathom limit—may be nearly as warm below as above. When, however, deep-sea soundings are made, when the registering thermometer is despatched on its mission of inquiry miles below the surface, then the report brought up is generally of great cold.

In almost all deeper parts, the tale is told of a frigid under-layer,—of water nearly and sometimes quite down to the freezing-point of fresh water. This, not only in Polar Seas, not only in Temperate Oceans, but in the hottest portions of the Tropics. The Atlantic, near the equator, is icy in its depths.

A reckoning has been made that, if the floor of the whole ocean, omitting shallower parts, could be divided into one hundred equal portions, ninety-two of those portions would be found covered by water at a temperature of less than 40° ; and only eight of them would lie under warm water. The vast mass of the ocean is cold, with a thin warm layer over certain districts.

Little doubt can there be that this under-layer is largely fed from polar regions.

We know that cold ocean-rivers pour from north-polar regions to the south, both in the Atlantic and in the Pacific. A general creeping under-flow of icy waters towards the equator evidently balances the general surface drift of warm waters towards the poles. Since cold water is heavier than warm, it would naturally find its way to lower depths, leaving the warm light liquid to float on the top.

In the Mediterranean Sea a marked contrast is found. There no ice-cold layer is spread over the bottom; and the water in its uttermost depths—over two miles and a quarter—does not sink below the temperature of 54° F. The heat of the sun in South Europe can hardly be compared with the heat of the sun over the Indian Ocean. Yet the latter has water far below the surface down to at least 35° .

Practically the Mediterranean, despite its depth, may be looked upon as an inland sea. The one opening which connects it with the open ocean is not only comparatively narrow, but also is shallow, being less than two hundred fathoms deep. The water on this dividing ridge remains at about 55° , and the Mediterranean throughout, to its greatest depths, keeps to about that same degree of warmth. No entrance is afforded to the heavy cold currents from polar regions.

The Red Sea is separated from the Indian Ocean by a similar ridge, and the same result is seen there. Over the floor of the Indian Ocean lies a carpet of chill water. But the whole body of the Red Sea never sinks, in summer or winter, below 70° F. Here, too, the cold streams are not able to surmount the barrier.

In many deep mid-ocean hollows, cut off by surrounding sub-ocean walls of rock, the same is found again—warm water within the hollow, cold water on the ocean-bed outside.

RIVERS IN THE SEA.

Actual Rivers in the Ocean; distinct streams of water, flowing over a bed of water, with banks of water. Not merely one or two such rivers, but scores of them, hundreds of them, great and small, in all parts of the world.

Chief perhaps in importance is the Gulf Stream, that vast flood which pours out of the Gulf of Mexico, and acts as a winter heating apparatus for the west of Europe. Though by no means the largest of ocean streams, it is one of the most useful to man.

After quitting the Gulf, it hurries at speed through the Straits of Florida; then spreads out into a river, about fifty miles wide and over two thousand feet deep, journeying at a rate of some sixty miles in twelve hours.

For a while it hugs the American coast; but, happily for Europe, it forsakes this friend of its youth, and wanders to the northeastward across the Atlantic.

To call it a "river" is no mere fiction of speech. Near Halifax the separation between warm and cold water is so sharp, that those on board a ship may know what lati-

tude they have reached, on entering or leaving the stream, by simply dipping a bucket in the water and taking the temperature. Literally the Gulf Stream is a warm river, flowing over a bed of cold water, with cold-water banks.

So far as Cape Hatteras the stream clings to its early friend; and after that the American coast knows it no more, being left to the mercies of a very different acquaintance. An icy stream flows southward from the far north, clinging to the coast of North America, while those in western Europe benefit by the presence of the warm current which travels over to them. This stream has been described as forming a "cold wall" to the mild Gulf Stream.

Fan-like, the Gulf Stream spreads as it journeys, growing gradually wider and wider, shallower and shallower, cooler and cooler—yet the last so slowly that, even off the coast of Scotland, water nine hundred fathoms deep is found to be at 40° F.

How strongly this mass of warm water affects the air above it is well known to sailors. When passing from the stream to the outside ocean, or from the ocean to the stream, they often change in a few hours from a warm to a cool or from a cool to a warm climate. The atmosphere is ever ready to tune its mood sympathetically to that of the ocean over which it sweeps.

But for the immense stores of heat carried northward, and given over to it, the English climate would be different indeed from what it now is. That is why their fellow-subjects in eastern and central Canada, living no farther from the equator than do the English, suffer from an intensity of cold in winter which they never endure. It is difficult to realize that parts of ice-bound Labrador and of Canada, where the thermometer often drops to 40° below zero, are no farther north than London and Paris; while Newfoundland lies actually more to the south than Erin's green Isle.

Turning to the Pacific Ocean, we find there a corresponding river, again flowing to the northeast. Just as the Gulf Stream wanders across the Atlantic, so this river wanders over the Pacific, carrying stores of tropical

warmth to opposite coasts. At its quickest, it is less rapid than the Gulf Stream, and about three times as wide. It too, as it journeys, becomes gradually broader, shallower, slower, colder.

This "Kuro Sivo" or "Black Stream," so named from its dark color, flows outside Japan, and then strikes freely for the northern coasts of North America. And because of its work as a winter heating apparatus in Alaska, the humming-bird is found at a latitude which, on the other side of the American Continent, means, not the play and whirr of humming-birds in a soft air, but the disporting of walruses among ice floes.

As in the Atlantic, so in the Pacific, the warm northward-travelling current is balanced by a cold southward-travelling current. The Arctic stream of the Pacific is not so marked as that of the Atlantic, perhaps partly because of the much shallower outlet from the Arctic Ocean; still it is quite chilly enough in its effects upon the Siberian climate. Here again the cold stream acts as a "wall" to the warm river flowing the other way.

More reasons than one may help to explain why these two currents slant off to the eastward instead of pouring due north. The shape of the various coastlines has something to do with it; also the presence of ridges and hollows in the ocean-beds, and the resistance of other contending currents. A river, either on land or in the sea, will always travel where it finds least opposition.

One main cause, however, is the whirl of our Earth upon its axis. This, which greatly affects the directions of prevailing winds, alters also the lines followed by ocean rivers.

A current starting from near the equator for the north shares in the rapid rush of the Earth's surface, which at the equator spins eastward at a rate of about one thousand miles each hour. As the volume of water gets farther north, it reaches parts of the Earth which are whirling more slowly, while it has not lost much of its own eastward whirl. A sideways flow is the result, changing the northward into a northeastward direction.

But a stream starting from the far north for the south

is affected in the opposite way. Near the north pole the Earth's surface hardly moves at all; and the southward-flowing current, being weighted with northern inertia, takes a contrary course to the current flowing north. It lags more and more *behind* the faster-revolving surface, and so wanders westward instead of eastward. Or, if prevented by the land from so doing, it hugs the coast which hinders it.

So the *pull* of the two great streams in the Atlantic is exactly opposed, each to the other. That of the Gulf Stream is towards the east; that of the Labrador Stream is towards the west; and the resolute manner in which the two refuse to mingle may be partly due to this fact.

If our Earth could be made to change the present whirl from west to east, and to revolve instead from east to west, those two great currents would alter their directions. The Gulf Stream would hug the American coasts, and the Labrador would find its way over to Europe. Then the British Isles in winter would know a temperature of 30° or 40° below zero, and the Canadians would experience soft damp winters and moderate summers. Perhaps they would no more welcome the exchange than would the English.

Then, too, the Black Stream would cling to the Asiatic side, transforming the climate of western Siberia, and the cold Arctic river would put a speedy end to humming-birds in Alaska. But abundance of ice floes would soon be awaiting the walruses, which would have to emigrate from the other side of the continent.

A good deal of discussion has been held as to whether England owes its mild climate to the Gulf Stream alone, or whether that Gulf Stream is merely a part of a general northward movement of Atlantic waters from the tropics towards the pole. The question has been warmly contested; and no doubt on both sides, as generally is the case, truth has been mixed with error.

The Gulf Stream cannot be viewed as a separate entity. Its very birth in the Gulf of Mexico depends on a great mass of water ever flowing from the southeast into the Caribbean Sea. Since so much water pours in, the same

volume must pour out, and as it does so it gains the name of the "Gulf Stream."

But after quitting the Gulf of Mexico the stream does not exist alone. It becomes a leading part of the North Atlantic circulation. The whole surface of that ocean is slowly turning round and round—"whirling as if stirred in the direction of the hands of a watch,"* and the Gulf Stream occupies one side or more of the vast *maelström*. In the centre of this revolving mass of water lies a district where the motion is slight, and at that centre floats an enormous collection of drift and seaweed called the Sargasso Sea.

Suppose we pour some water in a large basin, drop into it a handful of small leaves and chips, and make the whole spin gently with one hand. We shall then see how the chips and leaves will collect at the centre, and will float there, almost stationary. That is what happens, on a large scale, in the North Atlantic Ocean.

Other Oceans also have this steady circular movement, not of the whole body of water, but of the surface-water, down to a greater or less depth—precisely how deep one cannot say; it lessens gradually with increasing depth. The same is found also in the South Atlantic, in the North and South Pacific, and doubtless in the Indian Ocean.

To find its direction in any part, one need only lay a watch, face upwards, upon a map of the North Atlantic or the North Pacific. In both cases the water travels round *with* the watch-hands. In the South Atlantic and the South Pacific the flow is just in the opposite direction.

So both the Gulf Stream and the Black Stream are merely parts of a big oceanic whirlpool. Each ocean on Earth has its own system of circulation; and that system is part of a world-wide system. The waters are in perpetual and complicated motion. Streams pour incessantly hither and thither, to north and south, to east and west.

Two vast streams, known as the Equatorial Currents, nominally pour round the world, but really are best seen in the open Pacific, where for long distances no land med-

*Dr. H. R. Mill.

dles with their career. They flow steadily westward, one to the north and one to the south of the equator.

Between them flows a reverse stream, called the "Equatorial Counter Current." If a certain amount of water travels north, an equal quantity must travel south. Or if, as in this case, so much water runs in a westerly direction, a corresponding quantity has to run in an easterly direction. Water may be marvellously piled up here or there, by influences of land or of wind, but it cannot remain piled up, without efforts on the part of the ocean to restore the equilibrium.

Were the whole Earth covered by a single unbroken sheet of water, these drift currents might circle round and round the globe for ever, undisturbed in their working. But the Earth has lands as well as oceans; and when a current strikes a coast its course is altered, part at least being turned in a fresh direction.

Much discussion has taken place about the causes which bring these great Drift Currents into being.

Disturbing elements, many in number, may have had a hand in the matter. So soon as one part of the sea-surface becomes warmer than another part, movements are set going; the heavy cold water sinks, the light warm water rises, and streams are started from the one place to the other. There are also countless rivers pouring into the ocean, each helping to upset its equilibrium. Heavy downpours of rain raise the level of the sea here or there, inducing more currents.

But these are lesser causes. It is now recognized, as a fact beyond question, that the main power in starting and sustaining ocean-currents is that of Wind.

OCEAN-WEEDS.

BY

AGNES GIBERNE.

“Have hung
My dank and dripping weeds.”—Trans. HORACE.

“The tide is full, the moon lies fair
Upon the Straits; on the French Coast the light
Gleams, and is gone; the Cliffs of England stand,
Glimmering and vast, out in the tranquil bay.”

—MATTHEW ARNOLD.

SCATTERED through the vast Chalk-beds of Great Britain and the Continent of Europe are thousands of layers of FLINT, such layers as any of us may have seen intersecting the smooth white face of Chalk Cliffs. And as with Chalk, so with Flint—we at once find ourselves upon the track of Life.

Not indeed always of animal life. Sometimes vegetable life takes its place. Though the highest Vegetables stand on a lower level than the lowest Animals, they too have Life, and thereby they are entirely apart from the whole world of inanimate Nature.

Widely distinct are the Animal Kingdom and the Vegetable Kingdom; yet on the borderland between the two is found a hazy belt of uncertainty.

So gently does the one glide into the other that, though a line of demarcation does exist, it is not always easily made out. But the transition from the lowest form of that which *lives* to any and every form of that which has no Life is abrupt, absolute, precipitous. Here we see no quiet sliding of the one into the other, no wavering hesitancy as to whether a certain something may belong to this or that side of the dividing parapet.

The term “Vegetables,” used scientifically about Land Vegetation, includes all manner of growths, from the lichen to the forest tree. But by that word, used in connection with the Ocean, is meant, *not* cabbages and cauli-

From “The Romance of the Mighty Deep.” London and Philadelphia.

flowers, *not* garden-plants or forest-trees, but an enormous variety of Sea-Weeds.

And among ocean-vegetables of humblest form, flourishing in salt water, is that of Diatoms—Flint-makers.

It need not be imagined that the manufacture of Flint is a monopoly of the Diatom tribe. That would be a mistake.

There are small carbonate-of-lime building jelly-specks and carbonate-of-lime building jelly-polyps. But there are also little vegetable-growths in the sea which form carbonate-of-lime, and some of these add their quota to the work of rearing Coral-reefs.

We have now to do with small flint-building vegetable-growths. But there are also little animal jelly-specks in the sea which form flint.

So neither Carbonate-of-lime nor Flint can be spoken of as belonging *only* to Animal or *only* to Vegetable Life. They must both be described in general terms as the outcome of that which Lives.

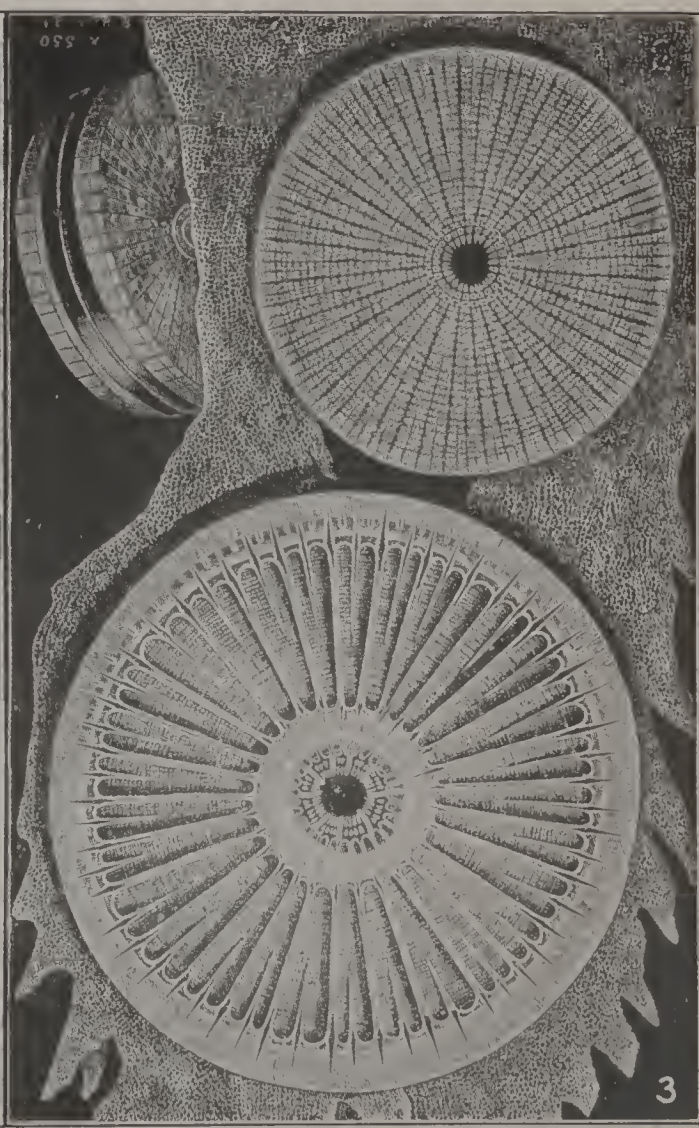
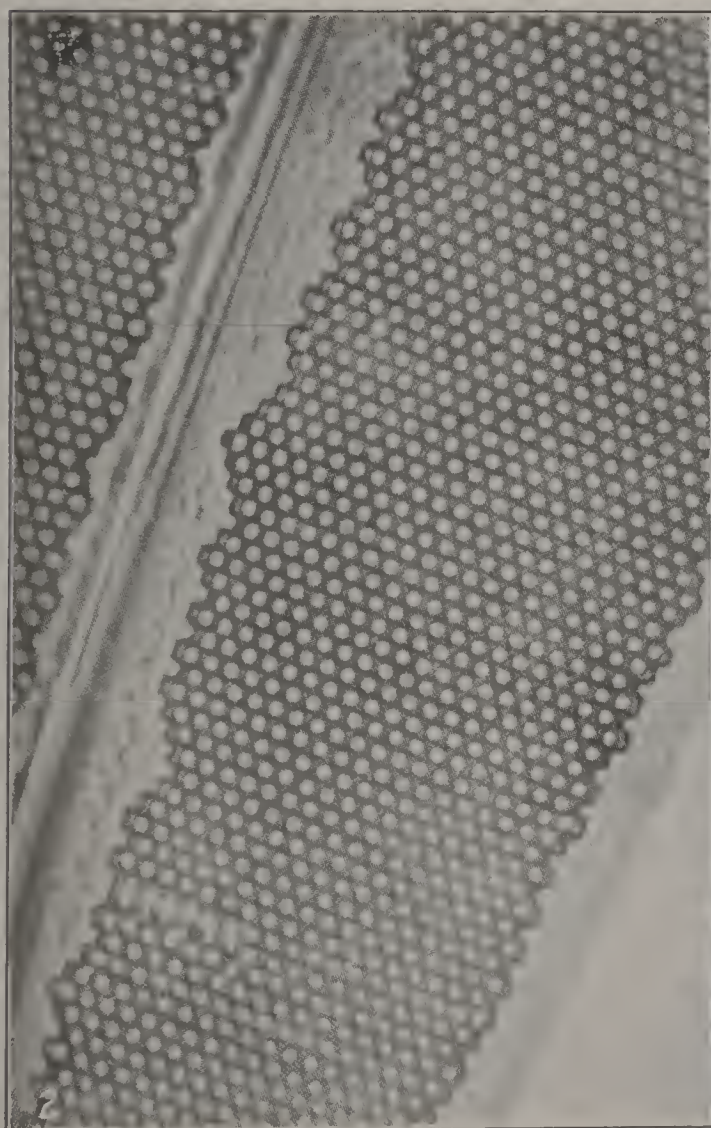
Among other Flint-builders in the ocean are the Radiolarians; living jelly-specks, and makers of the most exquisite shells, so tiny in size that millions of them may be packed into one cubic inch. These belong to the Animal Kingdom. They rank with the Foraminifera, differing from them chiefly in the fact that their shells or skeletons are formed of silica, not carbonate-of-lime.

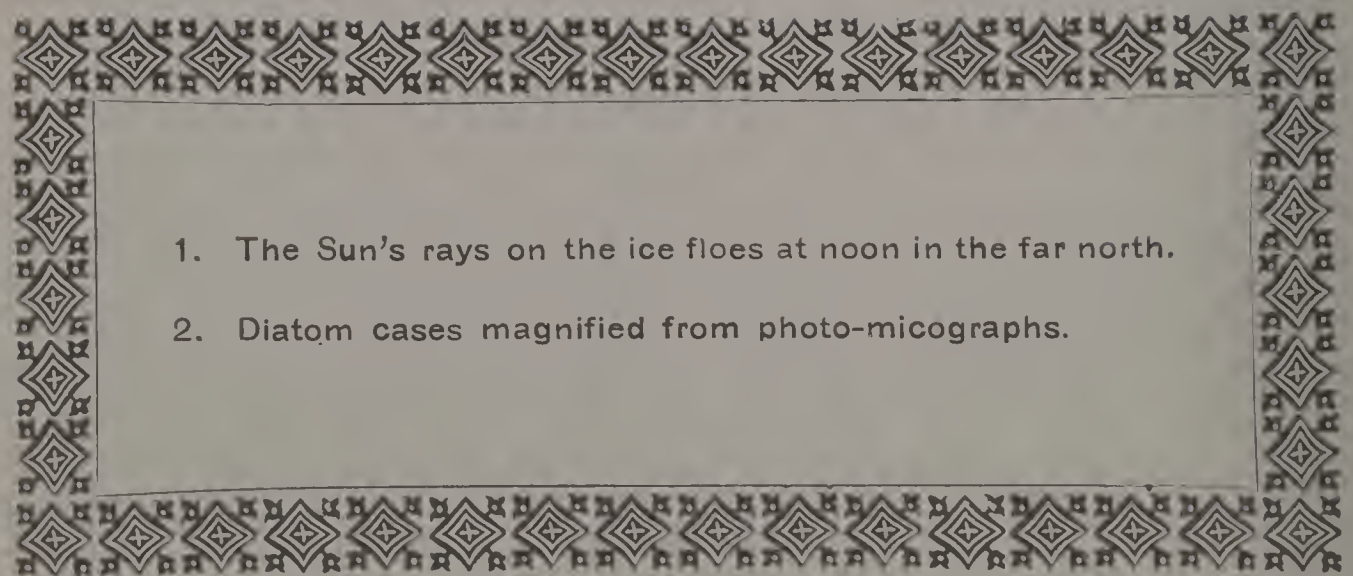
But in this chapter we are concerned with the Vegetable Life of the ocean, and we must therefore let the wonderful Radiolarians alone.

Properly the chapter on Vegetables ought to have come before any chapter on Animals, since we have been climbing upward from inanimate Nature, and since all vegetables rank below all animals. When on the topic of Ocean-building, however, the subject of Chalk seemed to follow naturally after that of Sandstone.

No surprise need be felt at vegetables being able to make or “secrete” flint and chalk. This making is, as we have seen, an unconscious work. The living jelly-speck secretes automatically, not with intention.

Such secreting is not confined to ocean vegetables.





1. The Sun's rays on the ice floes at noon in the far north.
2. Diatom cases magnified from photo-micrographs.

Trees and plants on land manufacture a host of substances—sweet oil, cocoanut milk, indiarubber, and countless others.* Forest trees in like manner grow their own framework of hard wood, which may be said to take the place with them of a skeleton.

All this is a part of LIFE. Inanimate rocks and stones may lie for centuries unchanged, except through friction with other rocks and stones, or with running water. But where Life reigns, though it be of the simplest kind, there growth and development must follow.

Life, from its very nature, cannot mean stagnation, or standing still. It must always be assimilating. It must always be expanding. It must always be doing. When these things cease, death has begun.

So much alike are the lower forms of life in the two classes, that many an animal has been for a time mistakenly called a vegetable, and many a vegetable has been for a while supposed to be an animal. The foraminifera were once ranked as vegetables, and the diatoms were ranked as animals.

In deep-sea regions, dark and cold, no vegetable life can possibly exist, not even the almost ubiquitous diatoms. As the tiny plant-life dies out, the little hard vegetable-cases sink to the ocean-bed, there to mingle with gathering muds and oozes—there, too, in the course of ages, to be transformed into Flint.

Diatoms flourish on land as well as in the ocean; in cold climates as well as in warm. On the whole they prefer the colder regions, therein differing from the warmth-loving foraminifera. Sometimes immense floating banks of these microscopic plants are found, reaching through many miles. A net, lowered into such a bank and then drawn up, is filled with a “brown-colored slimy and felt-like mass,” made up chiefly of uncountable myriads of diatoms.

Such masses are held together by a kind of sticky jelly, and if the hand is passed through it a very slight roughness may be perceptible, caused by the flinty diatom shells or cases.

*The spicules of silica may be seen on coarse grass, secreted by the grass.

Mere specks indeed they are, individually too minute to be seen by a human eye, unaided. Yet how marvellous in their make!

A Diatom plant or vegetable or sea-weed, whichever we choose to call it, is like a Foraminifer of the simplest possible structure. It consists of a single cell, with an outside flinty coating or inclosure, answering to the wood of a tree or the skeleton of an animal.

This flint casing, though infinitely small and delicate, is yet firm enough to prevent the passage of water through it; and also it is practically indestructible by ordinary forces. Diatom-cases, dropping to the ocean-bed, may lie there for ages.

The living cell is inclosed in the said "case," which is a kind of box, consisting of two halves or "frustules," neatly joined together by a ring or girdle.

Diatoms increase in numbers, like many of the Foraminifera, by simply dividing into two. When the living cell thus parts, each half takes as its share one side of the box, and each then makes another side, or "frustule," to complete itself. For this operation, the tiny ring or hoop doubles into a pair of hoops, one of which clings to each half of the case.

Perhaps in all the world no greater marvels are to be seen than these extraordinary minute vegetable-cases.

Minute? Yes. A mass of millions upon millions, held together, may be perceived and felt. But let a light scattering of them be dropped upon a slip of grass in broad daylight, and let a man of keen eyesight set himself to examine them. He will see—nothing! Not even an appearance of delicate dust. The diatoms are to him as if they did not exist.

Then let him put that fine scattering under a good microscope, changing lens after lens, to higher powers. A world of beauty, of finish, of originality, of unbounded variety in construction, will open out before him.

Each little shell is exquisitely shaped, exquisitely put together, exquisitely ornamented. Though thousands, nay, millions, of them might be packed into a cubic inch,

yet there has been no carelessness, no scamping, in the work, no saying, "Nobody will see, so anything will do."

The different kinds of Diatoms are innumerable; and each kind, each species, even each variety, has its own especial form, its own complex design, followed out and faithfully reproduced in hundreds of millions of individuals.

Pattern-markings, by which each variety is distinguished, formed of an infinitude of delicate lines and dots, arranged in every imaginable fashion, vary to an extent almost beyond conception. There are cases round, triangular, lengthy, many-sided, chain-like—but to picture them in words is hopeless. They have to be studied in their own wonderful minuteness and delicacy, complexity and loveliness, before they can be known. . . .

It seems that every individual of every separate kind has power to form certain shapes, with certain markings, and no more. It is as if upon each minute speck of vegetable life had been originally impressed its own—not *individual* character, but *class* character. This character unconsciously expresses itself in such and such a form of shell, just as with men the individual character expresses itself in such and such outlines of face. The same may be said of Foraminifera and Radiolarian shells.

Some Diatoms have a singular power of movement; and from this sprang early mistakes, through which they were wrongly classed as animals.

Many of them grow, like ordinary plants, fixed in one spot. But many others are in continuous and regular motion. Careful study has, however, made it clear that the movements of Diatoms are purely mechanical, purely involuntary, like those of some sensitive land-plants. It is probably due to the working of food, taken into the little organism, and not obedient to any *Will* on its part.

It may be that herein lies the great difference between a Diatom and a Foraminifer. The one exists, but has no approach to consciousness; or, at least, probably no approach to any power of choice. The other, though of the very lowest and feeblest type of Animal-life, may yet be supposed in its infinitesimal measure to have a *wish*,

and to be able to act upon that wish. But here we do not get beyond conjecture. Where Life exists, it *may* be that in all cases some dim form of consciousness exists also, which *may* involve some faint power of choice.

Flint-making, like Chalk-making, is not only an old-world and long-past operation, but a present one. Diatoms lived and died in ages gone by, and their remains are found hardened into flint. Diatoms live and die in these days; and their remains may yet, in centuries to come, be transformed into the same substance.

From Diatoms one might range upward through an enormous variety of Ocean-weeds, of all kinds and descriptions.

Though they are the "last and lowest of all the tribes of plants," yet it is a wide step from the undermost to the uppermost of even this humble Vegetable Tribe.

At least five or six thousand species of Sea-weeds are known to Naturalists. Each ocean, each lesser sea, has its own particular vegetation, largely affected by the varying degrees of saltiness, the warmth or coldness of the water, and the faster or slower currents which happen there to prevail.

Sea-weeds of all sizes are found, from the invisible diatoms to enormous growths in Pacific waters, reaching to yards upon yards in length, with solid trunk-like stems, and huge fronds like those of a tropical palm.

Near Tierra del Fuego immense growths have been seen, with stems between three and four hundred feet in length. Great sub-ocean forests of kelp are there, and floating fucus-islands, with leaves or fronds seven or eight feet from base to tip, covered with living animals, and having air-vessels several inches long.

In the matter of color no great variety exists. Sea-weeds are generally either grass-green, olive-brown, or red. The green are usually close to land, and they never grow beyond touch with direct sunlight. The olive-brown are the more abundant; and the red belong, perhaps, more often to deep water.

A large majority grow attached either to stones or to the shallow sea-bottom, but some kinds float unattached.

To this last class belong the masses of weed in the Sargasso Sea—the centre of the North Atlantic currents.

Round that huge collection of weeds and drift, which reaches over something like two hundred and sixty thousand square miles, the entire North Atlantic slowly revolves. And of these weeds—called “Sargassum”—none are attached to rock or ground, but all float loosely in mid-ocean. They seem to flourish thus, though the fact that fructification is not found upon them points to a somewhat unusual condition of things.

Sea-weeds more often multiply by means of spores,—a form of vegetable-growth inferior to that of seeds. All spore-growing plants, whether on land or in the sea, take a lower rank than seed-growing plants.

A still lower and humbler method is that of simply dividing into half.

There is yet another way by which ocean-weeds increase, and it reminds one curiously of the gardener’s plan of growth by cuttings.

In rough weather, on shallow reaches not far from land, the waves tear quantities of sea-weed fronds from their moorings, and carry them to shore or to rocky parts, where they become entangled, and are held fast.

There, if later waves do not again dislodge them, and if other circumstances are favorable, the wandering fronds settle down, attach themselves, and become fresh plants. So in this case the waves act as gardeners, and make cuttings of ocean-plants.

While plant-life in the ocean is plentiful in amount and abundant in variety, it is confined within limits. By far the greater part of Sea-weed existence is contained in the Hundred-fathom limit—that is, within six hundred feet of the surface. Not many kinds, indeed, can grow in anything like as much depth as five or six hundred feet.

Sea-weeds in abundance are found on shallow shores, near continents and islands; on the zone between high and low tides; and on gently-shelving slopes beyond that zone.

THE SEVEN WONDERS OF THE WORLD

Were formerly accounted to be: (1) The pyramids of Egypt, (2) the hanging gardens of Babylon, (3) the tomb of Mausōlos, (4) the temple of Diana at Ephesus, (5) the Colossus of Rhodes, (6) the statue of Zeus by Phidias, (7) the pharos of Egypt, or else the palace of Cyrus cemented with gold.

The pyramids first, which in Egypt were laid;
Next Babylon's garden, for Amytis made;
Then Mausōlos's tomb of affection and guilt;
Fourth, the temple of Dian, in Ephesus built;
The Colossos of Rhodes, cast in brass, to the sun;
Sixth, Jupiter's statue, by Phidias done;
The pharos of Egypt, last wonder of old,
Or palace of Cyrus, cemented with gold.

THE OLDEST PICTURE-BOOK OF ALL.

BY

E. WALTER MAUNDER,

ASSISTANT IN GREENWICH OBSERVATORY, ENGLAND.

THE oldest picture-book in our possession is the Midnight Sky.

We stand out under the stars on some clear moonless night, and looking upward, though no forms are visible, though it is only here and there that the natural grouping can by the utmost legitimate effort of fancy be made to fit some preconceived shape, yet we still seem to see the whole vast dome covered with mysterious frescoes. There in the north shine the two Bears, the unsleeping guardians of the Pole. Between them winds the Dragon. There stands Cepheus the king, and by his side, in mid-stream of the Milky Way, is seated Cassiopeia, his queen.

The figures overhead and to the south change with the changing hours and seasons, and the December midnight brings us the most glorious show of all. There is Orion; following him are Sirius and Procyon, his dogs; above are the Bull and Twins; and higher still, Auriga and Perseus join Cassiopeia on the Milky Way. Andromeda, chained to her rock, lies beneath her boastful mother; whilst her enemy, the great Sea Monster, is sinking down below the western horizon. The April nights give the predominance to Arcturus, the most brilliant of the constellation of Boötes the herdsman, who stands with one hand stretched towards the Crown, the other towards the Greater Bear. Beneath him lies the Virgin, while the Lion is rushing downwards towards the west.

The Scorpion is the lord of the south during the short summer nights, while the Lyre, with its bright blue jewel Vega, claims the zenith; and between, the two giant heroes, Ophiuchus and Hercules, spread their huge limbs. The September midnight is the time for Pegasus, and then the watery and fish-like constellations have their turn—the Dolphin, the Sea-Goat, Aquarius with his stream and the southern Fish, the twin Fishes, and fair Andromeda's huge marine persecutor.

We seem to see these forms, though no form nor semblance of the form is really there. For from a great antiquity men have looked upwards to the heavens and have pictured thereon, in their own thought, certain forms which we have inherited from them by long tradition; forms which became so real to them that the stars themselves, on which they based them, seem to fade out or to be but as the nails which kept the pictures in position, whilst the forms remained the real objects which filled the heavens.

The old figures and names, therefore, which are associated with the stars and which we now find on star-globes or in star-atlases, make up the oldest picture-book that has come down to us. Not all of these figures, however, are of great age. Many were made at the time of the revival of Astronomy three hundred years ago. But, knowing the history and origin of these, we can efface

them, and confine our inquiry to those constellations which have at least a respectable antiquity.

These are usually reckoned as being forty-eight in number, and a complete account of them is preserved to us in a scientific form in the catalogue of Claudius Ptolemy (A.D. 150), and in a literary form in the poem of Aratus (B.C. 260). These two authorities are in substantial but not absolutely complete accord; and it is the constellation forms, preserved to us by Aratus, and old even in his day, which make up "the oldest picture-book of all."

These old constellations, often called the "Greek Sphere," from the nation that has handed them down to us, are well known, and may be found described and catalogued in a hundred books of astronomy; and the questions as to who mapped them out, when, where, how, and why, have had a perennial interest. Much progress has been made towards an answer of late years, through researches into myths and folklore, and through the evidence supplied by the monuments of Egypt and the Euphratean valley. Yet, singularly enough, the evidence on these points offered by the constellations themselves—evidence more exact, trustworthy, and free from ambiguity than any to be derived from myths and monuments—has been strangely neglected.

The first feature which the old constellations present to us is a very striking one. They cover only a portion of the heavens, and a large region, roughly circular, in the southern hemisphere is left entirely vacant. This circumstance early caught the attention of astronomers, after the geographical discoveries of the Portuguese had brought not only new lands and new seas, but new heavens to their knowledge. But those astronomers looked upon this vacant place simply as an opportunity for constellation-making of their own; not at all for inquiring whether that space had any information to give them.

It was not until the nineteenth century had begun to dawn that any one seems to have appreciated the real significance of the neglect of the designers of the old con-

stellations to cover the entire sky, and even then it was left for one obscure writer—whose works are known to but three or four astronomers, his name to even fewer, and of whom the general public is wholly ignorant—to grasp the significance of this empty area in the southern heavens, and to see the consequences which it involved. More remarkable still, when once the solution had been offered, it passed unnoticed for some sixty years, until it drew the attention of the late R. A. Proctor, probably the acutest and clearest popular writer on astronomy that has ever lived. Yet even he, either because it did not attract him or because he was too fully occupied with other matters, by no means fully worked the subject out.

The writer in question was a Swede of the name of Carl G. Schwartz, who appears to have resided at Baku, on the Caspian Sea, at the end of the eighteenth and the beginning of the nineteenth century. Schwartz wrote a treatise in Swedish on the origin and meaning of the constellations, which was translated into French and passed through several editions. There were some absurdities in his work, and as these were only likely to enlist the sympathies of inhabitants of Baku and its neighborhood, they may account for the neglect with which the more thoughtful part of his book has been treated.

Briefly, Schwartz's position is this. The ancient astronomers left unmapped the stars in the extreme south, because they never saw them. They did not rise above their horizon. From this we learn the latitude in which those forgotten observers lived, since it must be equal to the radius of the unseen area. Here in London, for instance, we are $51\frac{1}{2}^{\circ}$ north of the Equator, and in consequence a star must be at least $51\frac{1}{2}^{\circ}$ north of the South Pole to rise above our horizon. Allowing for the uncertainties introduced by atmospheric absorption, by refraction, by the differences in brightness in the stars which would just rise above the southern horizon line, and by the probability that at least a few of the stars low down in the south would be neglected by the old astronomers, we can say certainly that they lived not further

south than N. lat. 36° , and not further north than N. lat. 42° .

This is in itself an important conclusion, for it enables us at once to set on one side the claims of either Egypt or Babylon to be the original home of the constellations, and—since in both countries the constellations described by Aratus were for the most part known and used—of their claims to be the original home of astronomy as well. So much for the place where the constellations were mapped. The vacant space gives us a not less useful indication of the time. For little by little, owing to the effect of precession, the poles of the heavens have shifted their places with respect to the stars, and the centre of that portion of the southern heavens which lies beneath our horizon to-day is far removed from the centre of that which was beyond the sight of the early constellation-makers. We have then simply to take the centre of the vacant space, and, allowing for precessional effect, to compute when it will have coincided with the southern pole, to know when the ancient work of constellation-making was completed. This gives us for date 2800 B.C. For place we have already found N. lat. $39^{\circ} \pm 3^{\circ}$. Necessarily there is an uncertainty of two or three centuries in the date; but, speaking in a broad and general way, the place and date of publication which our picture-book bears impressed upon it is N. lat. 39° and 2800 B.C.

So far Proctor, following Schwartz, worked out the problem; but he does not seem to have troubled to push the research further in other directions, or to have inquired as to the consequences of the results which he had obtained. Yet the constellation figures give us an indication of the longitude where they were planned, as well as of the latitude, though the indication is not quite so definite as in the case of the latter.

We infer this from the animals included among the figures of the Sphere. These we find to be the horse, bull, sheep, goat, dog, and hare. The carnivora are the bear and the lion. The eagle, hawk or vulture, and crow represent the birds. The serpent and water-snake are the reptiles, and the scorpion and crab represent the inverte-

brates. Of marine animals we have several fishes of indeterminate species, a dolphin, and a sea-monster which may not improbably represent a whale or a shark. Conspicuous by their absence are the elephant, the camel, the hippopotamus, the crocodile, and the tiger; and therefore, even if the question of latitude were not decisive, we should be warranted in rejecting India, Egypt, or Arabia as having been the birthplace of the Sphere. The presence of the lion probably warrants us in excluding Europe—that is to say, Greece, Italy, and Spain—from our search. We are thus shut up to but a single region—namely, that which we may briefly describe as Asia Minor and Armenia, and which is washed by the Black Sea on the north, by the Mediterranean on the south, by the Caspian on the east, and the *Ægean* on the west.

There is a further object among the constellation forms which is of great significance. It is the presence of a ship, and it certainly suggests that it is to one of the coasts of this country and not to its interior that we should look for the precise site of the observatory where the stars were first mapped out. Of the four seas mentioned, the Caspian is the one which would seem to have the greatest probability. The *Ægean* or Mediterranean would open to the sailors embarking upon them the possibility of sailing as far south as the thirty-first parallel, and would thus bring a considerable additional extent of the southern heavens within their knowledge. The Black Sea and Caspian, on the other hand, only extend northwards, and consequently their explorers would make no additions to the stars they knew at home. Of the two, seeing that the southern shore of the Black Sea is so very near the utmost northern limit which we can allow for the site of which we are in quest, while the Caspian extends across the entire belt in which it must be placed, the balance of probability lies rather with the latter.

It would well accord with a position water-bounded towards the north that Aratus consistently speaks of the northern horizon as the sea, though the very reverse was the case for his own country, Cilicia. Of the poles, he says:

"The one we see not; but the opposite
Is high o'er ocean in the north."

Of the two Bears and the Dragon, that

"on either side
His coil they move and dread the dark blue sea."*

But whether or no we regard Argo as a sufficient proof that the constellations were designed in a maritime district, its presence shows an acquaintance with the art of navigation. And we must remember that progress in practical astronomy is far more likely to have been due to the needs of the sailor than to the mysticism of the priest or the charlatanry of the astrologer.

The vacant space in the southern heavens is defined, of course, by the constellations which border it, *i.e.* by the most southerly. It is defined by them alone, and consequently the date and place inferred from that vacant space are, strictly speaking, the date and place of the southernmost constellations only. But these southern constellations would be the most difficult to form because the stars which make them up remain for so short a time above the horizon. The figures associated with them are also in every single instance connected with more northern figures. They were, therefore, probably the last designed. And as, if the work of constellation-making had been continued later than the time given, the effect of precession and of geographical discovery must have brought other regions of the southern heavens into view, we may take it that the place and date thus fixed are the place and date of the completion of the work; precisely as the date and place on the title-page of a book indicate when and where it was published in its completed form, though some of its chapters may have been written many years before and in an altogether different locality.

This leaves the question still open as to how long the constellation figures took in making. The work may have taken a single man a single year; it may have taken one man his entire lifetime; it may have taken a body of men many generations.

*Brown's "Aratus," pp. 14, 16.

There are some indications, which seem to have escaped notice hitherto, by which we may fix, roughly at least, the date of certain other constellations than those in the extreme south. These are the twelve commonly known as the Signs of the Zodiac, and which beyond all controversy were planned in order to mark out the Ecliptic.

The division of the zodiac into *twelve* signs is one of very great significance. The first astronomers could easily see that the moon moved among the stars, and after they had continued their observations for several years they would recognize that though she followed an apparently shifting path, yet this path did not wander very far north or very far south of a given circle of the heavens. That was a perfectly straightforward observation to make; and no doubt, at a very early age, twenty-seven or twenty-eight groups of stars were arranged around the sky through which the moon passed in the course of as many days—a sidereal month. The “Lunar Mansions” took their origin in this way, and from them the line of the ecliptic could no doubt have been determined.

But the twelvefold division of the zodiac brings quite another class of observation before us. The men who effected this had recognized that the sun, too, moved among the stars. Now this perhaps was the most difficult discovery which up to the present date has yet been made in astronomy. It is only the first step that costs. We have been taught it from childhood, and are not therefore in a condition to grasp the difficulties which must have beset the first workers in the science. But the man whose observation had been close enough, and whose intellect was keen enough to lead him to conclude that the stars, though so absolutely invisible to us by day, were yet shining down just as really as by night, must have been a very giant among men. It was the first great incursion of physical research into the invisible, the first great triumph of induction, the first time that appearances were set aside in favor of thought.

The significance of the zodiac, then, with its twelve-

fold division, is that it shows that the length of the year had been determined; that the path of the sun among the stars, with which it is never seen in company, had been marked out; and that a method had been discovered by which the position of the sun relative to the stars at any time could be ascertained. A complete parallelism between the motions of the sun and the moon had been established. Just precisely as the moon passed round the sky in a month and traversed a single "lunar mansion" in a day, so the sun too moved among the stars, making its circuit of the heavens in a year, and traversing a single sign of the zodiac in a month.

There was an astronomy, therefore, before the constellations, and one which had attained no mean development. We infer from the fact that the zodiac marks the ecliptic, and that it is divided into twelve signs, the number of months in the year, that it was devised in order to assist in the observation of the position of the sun among the stars. And we know in a variety of ways that this took place while the spring equinox was still in the constellation Taurus. We have for example the tradition preserved by Virgil in the well-known and often-quoted lines:

*"Candidus auratis aperit cum cornibus annum
Taurus." **

This was of course purely traditional in Virgil's day, for the equinoctial point had then passed entirely out of Taurus and very nearly out of Aries. Now we have no tradition whatsoever that the Twins ever led the year, and therefore we are sure that the zodiac is not later than 1800 B.C., and does not date farther back at the outside than to 4400 B.C.

There is another consideration which enforces the same conclusion. Of the twelve Signs of the Zodiac, five face definitely one way, four the other, the remaining three being indeterminate. These three are, the Balance, which necessarily gives us no hint of direction, the pair of Fishes, which, apparently as an integral part of their

**"Georg."* I. 217-8.

design, face different ways, and the Twins, the original direction of which is no longer certain. The other nine are divided into two systems, the one in which the signs all face east; the other in which they all face west. If the Zodiac was planned while the spring equinox fell in Taurus, then the sun was ascending all through the signs that face the east, and was descending all through the signs which face the west. The chances are great that such an arrangement is not accidental.

This range of 2,600 years is very considerable, but a closer examination of the Signs enables us to contract it very much. The Signs of the Zodiac are not of perfectly equal extent. Cancer, for instance, only represents about 19 degrees of longitude; Virgo covers about 43 degrees; and it happens that if we try to place the two equinoctial and the two solstitial points symmetrically among the twelve Signs, we find ourselves limited to a date of about 3100 B.C., with a possible range of about 300 years on either side. At this date, 5,000 years ago, the spring equinox was in the centre of the constellation of the Bull, the summer solstice in the centre of the Lion, the autumnal equinox in the centre of the Scorpion, and the winter solstice in the centre of the Water-pourer. In strict accord with this fact we find the Bull, the Lion, and to a less degree the Scorpion among the oldest and most widely diffused of solar symbols. Another note of time is afforded us by the four stars Aldebaran, Regulus, Antares, Fomalhaut, which have been known as "royal" stars for many ages. The significance of this title is perfectly obvious. It was given to them because at that time they were the bright stars nearest to the four cardinal points of the ecliptic. This again limits us to almost precisely the same period as that we have already found. About the year 3000 B.C. Aldebaran and Antares were both on the equinoctial colures. Four or five centuries earlier β Tauri would have challenged the right of Aldebaran to this title; an equal length of time later, and the Pleiades would have usurped it.

The date of the zodiac, therefore, may be taken as not very far from 3000 B.C.; but the zodiacal constellations,

with the Dragon, which marks out the pole of the ecliptic, must have been the first to be planned, since they had to be allotted to a definite region of the sky. The southern constellations which ring in the vacant space were as certainly the last. We may take it then as probable that the entire work did not take more than about 200 or 300 years, ending 2800 B.C., and that very probably it took much less.

This date, derived from several independent considerations, completely disposes of the theory of the origin of the constellations which still finds most general acceptance. Briefly it is this. The figures adopted for the twelve Signs of the Zodiac were chosen to denote the climatic character of the twelve months of the year; the stars through which the sun passed in the course of a certain month being given a symbol in accord with the chief characteristic of that month. Thus Aries, Taurus, and Gemini are supposed to represent the months of March, April, and May, the three spring months when the flocks and herds bring forth their young; or Aries may stand as the solar ram, the leader of the heavenly flock, while Taurus will represent the ploughing season. To June the sign of the Crab was given, so the theory has it, to represent the going backward of the sun after the solstice. The Lion represents the fierceness of the solar heat in July. The Virgin with the ear of corn in her hand is supposed to stand for August, assumed to be the harvest month. The Balance is to set forth the equality of day and night at the autumnal equinox in September. The Scorpion is taken to represent the fevers, which, for the purposes of the theory, are supposed to be especially destructive in October. The Archer denotes the hunting season in November; the Sea-goat the upward motion of the sun after the winter solstice in December. Aquarius of course denotes the rains of January, and the Fishes in February the reopening of rivers and lakes for fishing after the winter's ice.

The theory never had much to recommend it, for the system of identification between the seasons and the months was so loose that it has been made to fit equally

well for countries as diverse as Babylonia, India, and Egypt, none of which, however, can have been the original home of the Sphere. Next, it explained only the twelve Signs of the Zodiac, and these, as the constellations themselves abundantly show, are intimately connected with many of the extrazodiacal signs. Lastly, and this is a fatal objection, it assumes that the constellations were marked out when the four cardinal points were in Aries, Cancer, Libra, and Capricornus—that is to say, about 1000 B.C., instead of some 2,000 years earlier. We know for a certainty that Aries was not the leading sign of the zodiac but the last, when it was mapped out; that the summer solstice was not in Cancer, nor the winter in Capricorn; and that the Balance was far from the autumnal equinox. The whole system of explanation is vitiated from end to end.

There is a most interesting hint here of a great astronomical revolution. Five thousand years ago the zodiac was planned with the Bull of Taurus for its leader. Aries was then the last and least important of the twelve. The next view that we get of the state of astronomy is some 2,000 years later. The Ram of Aries is now the Prince of the Zodiac, Taurus has dropped to a second place, and the zodiac itself has suffered an important change. The old constellations, composed of the actual stars themselves and defined by them, unsymmetrical in position and unequal in extent, are represented by purely imaginary “Signs.” These have no direct reference to the stars, though they derive their names from the old constellations; they are perfectly symmetrical, and all are of precisely the same extent, 30 degrees of longitude, neither more nor less.

How that revolution came about we have at present no means of knowing; but it has hitherto interposed a great barrier to our learning either from classical literature or from myths or monuments anything trustworthy as to the true origin of the constellations, for the reason that the sources we have been consulting are, in consequence of that revolution, as ignorant of the matter as ourselves.

The only light therefore that we can at present gain

on the subject must be supplied to us by the constellations themselves, an inquiry in which again Carl Schwartz proved himself a pioneer.

First of all it is abundantly plain that though astronomers designed these forms, and no doubt used them, as they were used by Claudius Ptolemy, for the purpose of identifying stars, yet they strongly subordinated astronomical usefulness to other considerations. Sir John Herschel in a well-known passage scarcely puts the matter too strongly:

The constellations seemed to have been almost purposely named and delineated to cause as much confusion and inconvenience as possible. Innumerable snakes twine through long and contorted areas of the heavens, where no memory can follow them; bears, lions, and fishes, small and large, northern and southern, confuse all nomenclature.

If astronomical usefulness had been the sole idea, then undoubtedly the constellations would have been arranged to be as nearly as possible of the same size; to be compact, not sprawling; the figures connected with them would have been distinct and without repetition, or, if repeated, repeated only in distant parts of the sky; and most assuredly different constellations would not have been intermingled. Every one of these canons is repeatedly set at naught. The constellations are no more of equal area on the celestial globe than are the countries on the terrestrial. Argo and Ursa Major are the British and Russian Empires of the sky; the Triangle and the Arrow are its Roumania and Bulgaria. Hydra sprawls across more than one-fourth of the meridians; Draco meanders in and out between the Bears like some slow river traversing a plain. The Serpent is in two distinct portions, divided by Ophiuchus as the county of Cromarty is by Ross-shire. The rule that would exclude duplicate figures seems to have been violated out of set purpose. In the forty-eight constellations we have fifty-four figures, as some of the constellations contain two or more. Out of these fifty-four we find ten men, three women, two centaurs close together, five fish, all close together, two eagles close together and in immediate

neighborhood to the swan, two bears close together, two dogs close together, three snakes, two crowns, two goats, two streams. The designs that are not repeated are distinctly in the minority, being only sixteen out of the fifty-four.

The frequency with which designs are repeated, and especially with which they are repeated in close proximity to each other, cannot possibly be accidental. It may be due simply to the spirit of imitation, different designers working at different times and without any concerted plan, but the later being content to copy their predecessors. Or it may be due to deliberate purpose, in which case we can infer that the designs are significant not merely in their form but also in their position. We can see at once that, in some cases at least, the constellations were not planned without reference to each other. The twelve Signs of the Zodiac certainly were intended to form a single sequence and to mark out the course of the ecliptic. Nor do they stand alone in this respect. There are many cases of a clear and intimate connection between different constellations; indeed, there are only a few that are entirely isolated. The connection of the zodiacal constellations with those outside is in many cases most clear. The Bull is attacked by Orion, who tramples on the Hare; Aquarius pours his stream into the mouth of the Southern Fish; the Ram presses down the head of the Sea-monster, and holds the ribbon that unites the Fishes; and Sagittarius shoots an arrow at the Scorpion. Besides these we have the figures that tell the story of Perseus and Andromeda, and two most remarkable groups, one of which will be referred to later. The other is connected with the Scorpion. At the time and in the latitude where the constellations were formed, the observer, looking southward at midnight in spring, pictured to himself in the sky a gigantic scorpion. Above the scorpion, with his left foot pressed firmly down upon the animal's head, stood the figure of a man, round whose body a great snake was twining, that he was strangling with his hands. The head of the Serpent-carrier was formed of stars which lay near the zenith. Facing north-

ward, the observer conceived of a similar but not identical group before him there. The same stars which made up the head of Ophiuchus the Serpent-carrier were used again, at least in part, to mark out the head of a second hero, unknown by name to Aratus, but later identified with the Greek Hercules. He was kneeling on one knee, and pressed down with the other foot the head of the great northern Dragon. So that, facing south, one conflict was seen represented; facing north another, very similar, yet having distinctive features of its own. And, as if to increase the resemblance, each hero is attended by an eagle, the one waiting on Hercules being distinguishable from the other by the lyre which it carries.

Here, then, we have reduplication in a most striking form, and in this case it is clear that the double arrangement is part of the original design. For, however and whenever the constellations were devised, beyond all doubt the twelve ecliptic signs and the one round the ecliptic pole form the frame to which the others had to adapt themselves; so that of the seven constellations in this particular series, the two extreme ones—the Scorpion in the south and the Dragon in the north—are both ecliptic in character.

One unmistakable sign of being a single concerted work is afforded us by the forty-eight constellations of the Greek Sphere. The old constellations did not cover the entire sky. Considerable areas were left vacant here and there in the northern heavens, and, in the south, the effect of precession and of geographical discovery made men in the course of time acquainted with a large part of the unmapped sky; yet the number of the constellations was not added to, although there was the opportunity, almost the necessity, for so doing. Two of the border constellations which ring in the vacant southern area were of a nature to permit a very considerable extension without interfering with their design, and as more of the southern heavens became known they were continued southward. But no new constellations were formed. It was not until the great astronomical revolution of the sixteenth century A.D. had swept away all regard for the

old traditions of the science that the work of constellation-making was resumed, and, once started afresh, it went on with the greatest rapidity until no nook or corner from pole to pole was left unoccupied. We may see therefore—if the original work of constellation-making had been due to a number of independent astronomers, each following his own ideas, without any conjunction with the rest, as was the case with the modern constellation-making—that the work would certainly have been continued until the whole of the northern heavens were covered, and the process would have gone on in the south as fast as new stars came into view. The cessation of the process for 3,500 years, despite the strong reasons for continuing it, is the most decisive proof that the work of constellation-making came from a single authority and had been carried out on a single plan.

The interdependence of so many of the designs, and the fact that the Sphere is thus manifestly the work of a single authority, furnish reasons for thinking that it was intended to be of the nature of a document. An examination of the individual forms supports this conclusion. We find, for instance, that three of the designs are truncated—the Bull, the Flying Horse, and the Ship are only half shown. Now this was not because there was not room enough to complete the design. There are many constellations much smaller than these in which the figure is complete; there are several, on the other hand, that cover a much greater area of sky than either Taurus or Pegasus. The fact that nearly all the constellations, as originally designed, were upright on the meridian, suggests a purpose in the recumbent attitudes of Virgo and Andromeda, while Pegasus was most assuredly not put upside down by accident. The stars that make up the figure are practically symmetrical, the four principal marking out the angles of a great square, so that the design would have fitted the stars just as well if Pegasus had been placed right way up.

Some of the forms represented are most clearly symbolical, for they are composite or monstrous in character. We have, for example, three female figures: Andromeda—

a woman naked and chained; Cassiopeia—a woman clothed, seated, and crowned; and Virgo, a woman clothed and winged. It cannot be pretended that there is anything whatsoever in the stellar configurations to suggest, first of all, the idea of a woman in these three places, and next, the characteristics which have been ascribed to each of them. There must have been some special purpose in ascribing wings to the Virgin; there must have been a purpose not less definite in representing Andromeda and Cassiopeia in positions so sharply contrasted.

Again, we have two Centaurs—monstrous figures, half man and half horse. Yet whoever designed the Sphere knew perfectly well that a horse and its rider were different and separate beings, for we have in Pegasus a riderless horse. So, on the other hand, the wings given to Pegasus and refused to Sagittarius and Centaurus must have been as intentional as the wings given to Virgo and refused to Andromeda and Cassiopeia. Again, the fish-tail in which Capricornus terminates must have been given him with a purpose, for Capella, the goat which Auriga carries, is of the ordinary form.

The attitudes of the figures are often clearly symbolical. Two instances are especially striking, Aquarius and Pisces. In the one, Aquarius pours out a stream of water, not upon a plant or tree or some land object, as would assuredly have been the case had Aquarius been meant to represent the rainy season, but upon a fish, and the fish, so far from swimming in the stream, drinks it, swallowing the entire stream. The Fishes afford a spectacle quite as strange, for they are tied together by a long cord, the ends of which are fastened round their tails. It is scarcely possible to imagine two designs which, taken baldly and literally as they stand, could be more unnatural and absurd, and it is astonishing that they have been preserved to us with these strange characteristics undisturbed for nearly 5,000 years. We can only account for their origin, we can only account for their preservation, by supposing that they were intended as hieroglyphics or symbols, and not as actual pictures; and

that the tradition that this was so was current long after the significance of the symbols had been entirely forgotten.

Perhaps the most remarkable group of constellations is one to which the late R. A. Proctor drew special attention. It consists of the constellations Argo, Centaurus, Lupus, Ara, and Sagittarius. The Centaur has apparently just left the Ship which is grounded on a rock, and is offering up on the altar the animal which we now know as the Wolf, but the exact nature of which was not known to Aratus, just as the constellation which we now call Hercules was to him simply the "Kneeler," and that which we now call the Swan, simply the "Bird." The smoke arising from the altar is admirably represented by the Milky Way, and right in the centre of the bright cloud it forms is placed the Bow—*i.e.* that of Sagittarius. When we compare these figures with the narrative given us in the eighth and ninth chapters of Genesis, we cannot, I think, resist Proctor's conclusion that we have in both instances the attempt to set forth the same story. The question is, which came first—the story or the constellations. If we say the story, then the constellations are fully explained; they are a picture of what was, at least at that time, believed to be a history. If the constellations came first it only leaves the question of their origin and meaning involved in more obscurity than ever.

Proctor in a half-hearted way hints his opinion that the story of the Deluge in Genesis is simply an attempt to "write up" to the figures inscribed on the walls of some zodiacal temple. I venture to think this an utter absurdity. There is no legend whatsoever so widely diffused and so generally consistent in its main details as that of the Deluge. To suppose that it took its origin in a tale written to account for the figures on a single temple is monstrous; while we actually know from the discoveries of George Smith that a story of the Deluge most closely related to that preserved in Genesis was held by nations bordering on the lands where the constellations took their origin, and at much the same date that we have found for them.

But if the story of the Deluge is intended to be set forth in these constellations, then we have without doubt lighted on the general secret of their origin. For the Deluge story is not the only one plainly referred to. The story of Perseus and Andromeda is set forth with great distinctness, and is marked out as a separate narrative by being framed by the equator and two of the colures, a quarter of the northern heavens being thus entirely devoted to it. The attitude of Ophiuchus strangling the snake, and crushing the scorpion's head with one foot while the latter stings him in the other heel, seems as direct a reference to the story of Genesis iii.

To sum up, this oldest picture-book of all was designed nearly 5,000 years ago by a people dwelling somewhere between the *Ægean* and the *Caspian*, which domesticated the bull, the sheep, the goat, the dog, and the horse; which hunted the bear, the lion, and the hare, and used the bow and the spear. Yet a people not merely nomadic, but either maritime themselves or at least acquainted with the ocean and with navigation. They had made not a little progress in Astronomy, for they had determined the length of the year and had carried the science of observation so far that they could recognize the position of the sun relative to the various ecliptic groups of stars. Their religion involved the erection of altars and the rite of sacrifice. They were acquainted with stories of the Fall and of the Deluge substantially the same as those preserved to us in the early chapters of Genesis, and they devised many of the constellations to give appropriate and permanent record of them; no doubt because they were included, as with ourselves, in their sacred history. The people was an organized one; having some definite and recognized authority, whether king, priest, patriarch, or council does not appear, but of that authority the work of constellation-making received beyond doubt the express sanction.

We cannot tell whether the designs in this book have come to us entirely without alteration. There is some question about the zodiacal sign of the Balance. We do not know whether the two Bears were originally bears,

wagons or chariots, or flocks of sheep; and so also with two or three other groups. But many significant little details seem to show that the constellations, considered as an entire document, have been preserved to us without important change.

Many of the constellations, then, were mapped out to express the religious belief of their designers. No doubt the others, of which at present we have no explanation, had just the same purpose. But though at present their interpretation seems to lie beyond us, we may well hope that further investigation into the science and religion of the Upper Euphratean Valley may ere long enable us throughout to

“read the page
Where every letter is a glittering world.”

WONDERS OF THE AURORA.

BY

RICHARD A. PROCTOR.

THE brilliant streamers of colored light which wave at certain seasons over the heavens have long since been recognized as among the most singular and impressive of all the phenomena which the skies present to our view. There is something surpassingly beautiful in the appearance of the true “auroral curtain.” Fringed with colored streamers, it waves to and fro as though shaken by some unseen hand. Then from end to end there pass a succession of undulations, the folds of the curtain interwrapping and forming a series of graceful curves. Suddenly, and as by magic, there succeeds a perfect stillness, as though the unseen power which had been displaying the varied beauties of the auroral curtain were resting for a moment. But even while the motion of the curtain is stilled we see its light mysteriously waxing and waning. Then, as we gaze, fresh waves of disturbance traverse the magic canopy. Startling

From “Light Science for Leisure Hours.”

coruscations add splendor to the scene, while the noble span of the auroral arch, from which the waving curtain seems to depend, gives a grandeur to the spectacle which no words can adequately describe. Gradually, however, the celestial fires which have illuminated the gorgeous arch seem to die out. The luminous zone breaks up. The scene of the display becomes covered with scattered streaks and patches of ashen grey light, which hang like clouds over the northern heavens. Then these in turn disappear, and nothing remains of the brilliant spectacle but a dark smoke-like segment on the horizon.

Such is the aurora as seen in arctic or antarctic regions, where the phenomenon appears in its fullest beauty. Even in our own latitudes, however, strikingly beautiful auroral displays may sometimes be witnessed. Yet those who have seen the spectacle presented near the true home of the aurora, recognize in other auroras a want of the fulness and splendor of color which form the most striking features of the arctic and antarctic auroral curtains.

Physicists long since recognized in the aurora a phenomenon of more than local, of more even than terrestrial, significance. They learned to associate it with relations which affect the whole planetary scheme. Let us inquire how this had come about.

So long as men merely studied the appearances presented by the aurora, so long, in fact, as they merely regarded the phenomenon as a local display, they could form no adequate conception of its importance. The circumstance which first revealed something of the true character of the aurora was one which seemed to promise little.

Arago was engaged in watching from day to day, and from year to year, the vibrations of the magnetic needle in the Paris Observatory. He traced the slow progress of the needle to its extreme westerly variation, and watched its course as it began to retrace its way towards the true north. He discovered the minute vibration which the needle makes each day across its mean position. He noticed that this vibration is variable in extent, and

so he was led to watch it more closely. Thus he had occasion to observe more attentively than had yet been done the sudden irregularities which occasionally characterize the daily movements of the needle.

All this seems to have nothing to do with the auroral streamers; but we now reach the important discovery which rewarded Arago's patient watchfulness.

In January, 1819, he published a statement to the effect that the sudden changes of the magnetic needle are often associated with the occurrence of an aurora. I give the statement in his own words, as translated by General Sabine:—"Auroras ought to be placed in the first rank among the causes which sometimes disturb the regular march of the diurnal changes of the magnetic needle. These do not, even in summer, exceed a quarter of a degree, but when an aurora appears, the magnetic needle is often seen to move in a few instants over several degrees." "During an aurora," he adds, "one often sees in the northern region of the heavens luminous streamers of different colors shoot from all points of the horizon. The point in the sky to which these streamers converge is precisely the point to which a magnetized needle suspended by its centre of gravity directs itself. . . . It has, moreover, been shown that the concentric circular segments, almost similar in form to the rainbow, which are usually seen previous to the appearance of the luminous streamers, have their two extremities resting on two parts of the horizon which are equally distant from the direction towards which the needle turns; and the summit of each arc lies exactly in that direction. *From all this, it appears, incontestably, that there is an intimate connection between the causes of auroras and those of terrestrial magnetism.*"

This strange hypothesis was, at first, much opposed by scientific men. Amongst others, the late Sir David Brewster pointed out a variety of objections, some of which appeared at first sight of great force. Thus, he remarked that magnetic disturbances of the most remarkable character have often been observed when no aurora has been visible; and he noticed certain peculiarities in

the auroras observed near the polar regions, which did not seem to accord with Arago's view.

But gradually it was found that physicists had mistaken the character of the auroral display. It appeared that the magnetic needle not only swayed responsively to auroras observable in the immediate neighborhood, but to auroras in progress hundreds or even thousands of miles away. Nay, as inquiry progressed, it was discovered that the needles in our northern observatories are swayed by influences associated even with the occurrence of auroras around the southern polar regions.

In fact, not only have the difficulties pointed out (very properly, it need hardly be remarked) by Sir David Brewster been wholly removed; but it has been found that a much closer bond of sympathy exists between the magnetized needle and the auroral streamers than even Arago had supposed. It is not merely the case that while an auroral display is in progress the needle is subject to unusual disturbance, but the movements of the needle are actually synchronous with the waving movements of the mysterious streamers. An aurora may be in progress in the north of Europe, or even in Asia or America, and as the colored banners wave to and fro, the tiny needle watched by patient observers at Greenwich or Paris, will respond to every phase of the display.

And I may notice in passing that two very interesting conclusions follow from this peculiarity. First, every magnetic needle over the whole earth must be simultaneously disturbed; and secondly, the auroral streamers which wave across the skies of one country must move synchronously with those which are visible in the skies of another country, even though thousands of miles may separate the two regions.

But I must pass on to consider further the circumstances which give interest and significance to the strange discovery which is the subject of this paper.

Could we only associate auroras with terrestrial magnetism, we should still have done much to enhance the interest which the beautiful phenomenon is calculated to excite. But when once this association has been estab-

lished, others of even greater interest are brought into recognition. For terrestrial magnetism has been clearly shown to be influenced directly by the action of the sun. The needle in its daily vibration follows the sun, not indeed through a complete revolution, but as far as the influence of other forces will permit. This has been abundantly confirmed, and is a fact of extreme importance in the theory of terrestrial magnetism. Wherever the sun may be, either on the visible heavens or on that half of the celestial sphere which is at the moment beneath the horizon, the end of the needle nearest to the sun makes an effort (so to speak) to point more directly towards the great ruling centre of the planetary scheme. Seeing, then, that the daily vibration of the needle is thus caused, we recognize the fact that the disturbances of the daily vibration may be referred to some peculiarity of the solar action.

It was not, therefore, so surprising as many have supposed, that the increase and diminution of these disturbances, in a period of about eleven years, should be found to correspond with the increase and diminution of the number of solar spots in a period of equal length.

We already begin to see, then, that auroras are associated in some mysterious way with the action of the solar rays. The phenomenon which had been looked on for so many ages as a mere spectacle, caused perhaps by some process in the upper regions of the air, of a simply local character, has been brought into the range of planetary phenomena. As surely as the brilliant planets which deck the nocturnal skies are illuminated by the same orb which gives us our days and seasons, so they are subject to the same mysterious influence which causes the northern banners to wave resplendently over the star-lit depths of heaven. Nay, it is even probable that every flicker and coruscation of our auroral displays corresponds with similar manifestations upon every planet which travels round the sun. It becomes, then, a question of exceeding interest to inquire what is the nature of the mysterious apparition which from time to time illuminates our skies. We have learnt something of the laws according to which the

aurora appears; but what is its true nature? What sort of light is that which illuminates the heavens? Is there some process of combustion going on in the upper regions of our atmosphere? Or are the auroral streamers electric or phosphorescent? Or, lastly, is the light simply solar light reflected from some substance which exists at an enormous elevation above the earth?

All these views have from time to time found supporters among scientific men. It need hardly be said that what we now know of the association between auroral action and some form of solar disturbance, would at once enable us to reject some of these hypotheses. But we need not discuss the subject from this point of view, because a mode of research has recently been rendered available which at once answers our inquiries as to the general character of any kind of light. I proceed to consider the application of this method to the light from the auroral streamers.

The spectroscope, or, as we may term the instrument, the "light-sifter," tells us of what nature an object which is a source of light may be. If the object is a luminous solid or liquid, the instrument converts its light into a rainbow-colored streak. If the object is a luminous vapor, its light is converted into a few bright lines. And lastly, if the object is a luminous solid or liquid shining through any vapors, the rainbow-colored streak again makes its appearance, but it is now crossed by dark lines, corresponding to the vapors which surround the object and absorb a portion of its light.

But I must not omit to notice two circumstances which render the interpretation of a spectrum somewhat less simple than it would otherwise be.

In the first place, if an object is shining by reflected light its spectrum is precisely similar to that of the object whose light illuminates it. Thus we cannot pronounce positively as to the nature of an object merely from the appearance of its spectrum, unless we are quite certain that the object is self-luminous. For example, we observe the solar spectrum to be a rainbow-colored streak crossed by a multitude of dark lines, and we conclude accordingly

that the sun is an incandescent globe shining through a complex vaporous atmosphere. We feel no doubt on this point, because we are absolutely certain that the sun is self-luminous. Again, we observe the spectrum of the moon to be exactly similar to the solar spectrum, only, of course, much less brilliant. And here also we feel no doubt in interpreting the result. We know, certainly, that the moon is not self-luminous, and therefore we conclude with the utmost certainty that the light we receive from her is simply reflected solar light. So far all is clear. But now take the case of an object like a comet, which may or may not be self-luminous. If we find that a comet's spectrum resembles the sun's—and this is not altogether a hypothetical case, for a portion of the light of every comet yet examined does in reality give a rainbow-colored streak resembling the solar spectrum—we cannot form, in that case, any such positive conclusion. The comet may be a self-luminous body; but, on the other hand, its light may be due merely to the reflection of the solar beams. Accordingly, the spectroscopist always accompanies the record of such an observation with an expression of doubt as to the real nature of the object which is the source of light.

Secondly, when an electric spark flashes through any vapor, its light gives a spectrum which indicates the nature, not only of the vapor through which the spark has passed, but of the substances between which the spark has travelled. Thus, if we cause an electric flash to pass between iron points through common air, we see in the spectrum the numerous bright lines which form the spectrum of iron, and in addition we see the bright lines belonging to the gases which form our atmosphere.

Both the considerations above discussed are of the utmost importance in studying the subject of the auroral light as analyzed by the spectroscope, because there are many difficulties in forming a general opinion as to the nature of the auroral light, while there are circumstances which would lead us to anticipate that the light is electric.

I notice also in passing that we owe to the Swedish

physicist Angström a large share of the researches on which the above results respecting the spectrum of the electric spark are founded. The reader will presently see why I have brought Angström's name prominently forward in connection with the interesting branch of spectroscopic analysis just referred to. If the discovery we are approaching had been effected by a tyro in the use of the spectroscope, doubts might very reasonably have been entertained respecting the exactness of the observations on which the discovery rests.

It was suggested many years ago, long indeed before the true powers of spectroscopic analysis had been revealed, that perhaps if the light of the aurora were analyzed by the prism, evidence could be obtained of its electric nature. The eminent meteorologist Dové remarked, for instance, that "the peculiarities presented by the electric light are so marked that it appears easy to decide definitely by prismatic analysis whether the light of the aurora is or is not electric." Singularly enough, however, the first proof that the auroral light is of an electric nature was derived from a very different mode of inquiry. Dr. Robinson, of Armagh, discovered in 1858 (a year before Kirchhoff's recognition of the powers of spectroscopic analysis) that the light of the aurora possesses in a peculiar degree a property termed fluorescence, which is a recognized and characteristic property of the light produced by electrical discharges. "These effects," he remarks of the appearances presented by the auroral light under the tests he applied, "were so strong in relation to the actual intensity of the light, that they appear to afford an additional evidence of the electric origin of the phenomenon."

Passing over this ingenious application of one of the most singular and interesting properties of light, we find that the earliest determination of the real nature of the auroral light—or rather of its spectrum—was that effected by Angström. This observer took advantage of the occurrence of a brilliant aurora in the winter of 1867-68 to analyze the spectrum of the colored streamers. *A single bright line only was seen!* Otto Struve, an

eminent Russian astronomer, shortly afterwards made confirmatory observations. At the meeting of the Royal Astronomical Society in June, 1868, Mr. Huggins thus described Struve's results:—"In a letter, M. Otto Struve has informed me that he has had two good opportunities of observing the spectrum of the aurora borealis. The spectrum consists of one line, and the light is therefore monochromatic. The line falls near the margin of the yellow and green portions of the spectrum. . . . This shows that the monochromatic light is greenish, which surprised me; but General Sabine tells me that in his polar expeditions he has frequently seen the aurora tinged with green, and this appearance corresponds with the position of the line seen by Mr. Struve."

The general import of this observation there is no mistaking. It teaches us that the light of the aurora is due to luminous vapor, and we may conclude, with every appearance of probability, that the luminosity of the vapor is due to the passage of electric discharges through it. It is, however, possible that the position of the bright line may be due to the character of the particles between which the discharges take place.

But the view we are to take must depend upon the position of the line. Here a difficulty presents itself. There is no known terrestrial element whose spectrum has a bright line precisely in the position of the line in the auroral spectrum. And mere proximity has no significance whatever in spectroscopic analysis. Two elements differing as much from each other in character as iron and hydrogen may have lines so closely approximating in position that only the most powerful spectroscope can indicate the difference. So that when Ångström remarks that the bright line he has seen lies slightly to the left of a well-known group of lines belonging to the metal calcium (the principal ingredient of common chalk), we are by no means to infer that he supposes the substance which causes the presence of the bright line has any resemblance to that element. Until we can find an element which has a bright line in its spectrum absolutely coincident with the bright line detected by Ång-

ström in the spectrum of the aurora,* all speculation as to the real nature of the vapor in which the auroral electric discharge takes place, or of the substances between which the spark travels, is altogether precluded.

It was supposed after the total solar eclipse of 1869 that the spectrum of the sun's corona exhibited the same bright lines as the aurora. But recent observations show that the coincidence is not so close as had been supposed, and, in fact, there is no evidence to show that the lines are the same.

CLOUDS, RAINS, AND RIVERS.

BY

PROFESSOR JOHN TYNDALL.

1. Every occurrence in Nature is preceded by other occurrences which are its causes, and succeeded by others which are its effects. The human mind is not satisfied with observing and studying any natural occurrence alone, but takes pleasure in connecting every natural fact with what has gone before it, and with what is to come after it.

2. Thus, when we enter upon the study of rivers and glaciers, our interest will be greatly augmented by taking into account not only their actual appearances, but also their causes and effects.

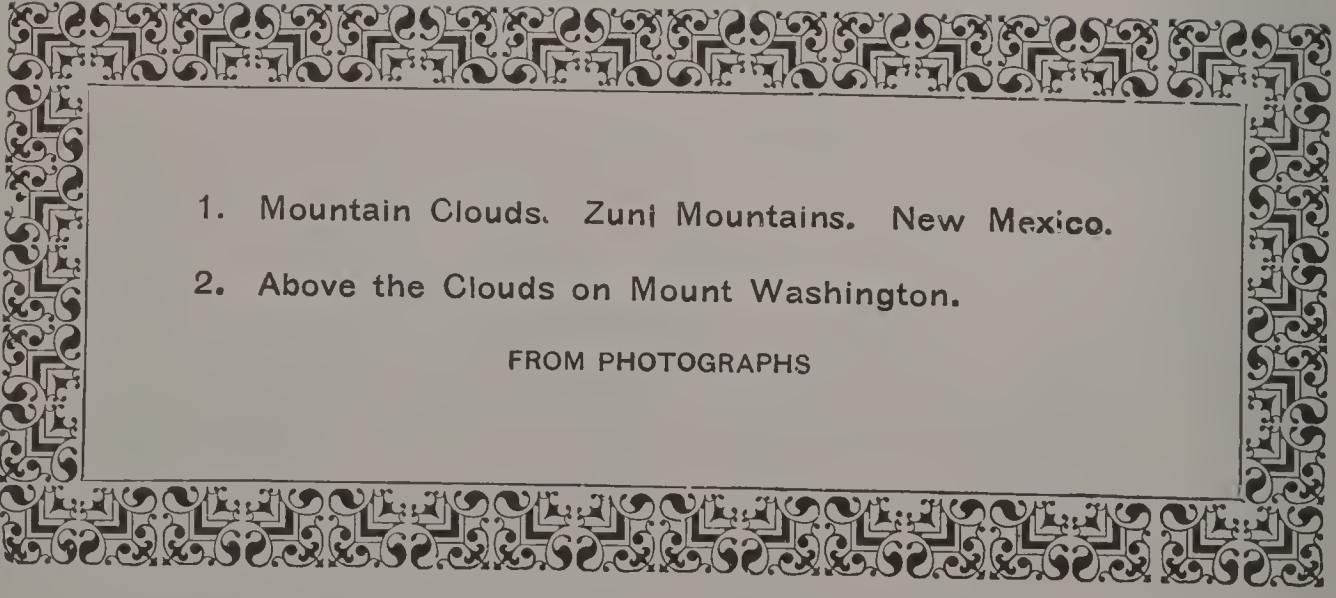
3. Let us trace a river to its source. Beginning where it empties itself into the sea, and following it backwards, we find it from time to time joined by tributaries which swell its waters. The river of course becomes smaller as these tributaries are passed. It shrinks first to a brook, then to a stream; this again divides itself into a number of smaller streamlets, ending in mere threads of water. These constitute the source of the river, and are usually found among hills.

4. Thus the Severn has its source in the Welsh Mountains; the Thames in the Cotswold Hills; the Danube in

*Other green lines have since been discovered in the auroral spectrum; and occasionally a red line is seen.

From "Forms of Water."



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1. Mountain Clouds. Zuni Mountains. New Mexico.
 2. Above the Clouds on Mount Washington.

FROM PHOTOGRAPHS

the hills of the Black Forest; the Rhine and the Rhone in the Alps; the Ganges in the Himalaya Mountains; the Euphrates near Mount Ararat; the Garonne in the Pyrenees; the Elbe in the Giant Mountains of Bohemia; the Missouri in the Rocky Mountains, and the Amazon in the Andes of Peru.

5. But it is quite plain that we have not yet reached the real beginning of the rivers. Whence do the earliest streams derive their water? A brief residence among the mountains would prove to you that they are fed by rains. In dry weather you would find the streams feeble, sometimes indeed quite dried up. In wet weather you would see them foaming torrents. In general these streams lose themselves as little threads of water upon the hillsides; but sometimes you may trace a river to a definite spring. The river Albula in Switzerland, for instance, rushes at its origin in considerable volume from a mountain side. But you very soon assure yourself that such springs are also fed by rain, which has percolated through the rocks or soil, and which, through some orifice that it has found or formed, comes to the light of day.

6. But we cannot end here. Whence comes the rain which forms the mountain streams? Observation enables you to answer the question. Rain does not come from a clear sky. It comes from clouds. But what are clouds? Is there nothing you are acquainted with which they resemble? You discover at once a likeness between them and the condensed steam of a locomotive. At every puff of the engine a cloud is projected into the air. Watch the cloud sharply: you notice that it first forms at a little distance from the top of the funnel. Give close attention and you will sometimes see a perfectly clear space between the funnel and the cloud. Through that clear space the thing which makes the cloud must pass. What, then, is this thing which at one moment is transparent and invisible, and at the next moment visible as a dense opaque cloud?

7. It is the steam or vapor of water from the boiler. Within the boiler this steam is transparent and invisible; but to keep it in this invisible state a heat would be re-

quired as great as that within the boiler. When the vapor mingles with the cold air above the hot funnel it ceases to be vapor. Every bit of steam shrinks, when chilled, to a much more minute particle of water. The liquid particles thus produced form a kind of water-dust of exceeding fineness, which floats in the air, and is called a cloud.

8. Watch the cloud-banner from the funnel of a running locomotive; you see it growing gradually less dense. It finally melts away altogether, and if you continue your observations you will not fail to notice that the speed of its disappearance depends upon the character of the day. In humid weather the cloud hangs long and lazily in the air; in dry weather it is rapidly licked up. What has become of it? It has been reconverted into true invisible vapor.

9. The drier the air, and the hotter the air, the greater is the amount of cloud which can be thus dissolved in it. When the cloud first forms, its quantity is far greater than the air is able to maintain in an invisible state. But as the cloud mixes gradually with a larger mass of air it is more and more dissolved, and finally passes altogether from the condition of a finely divided liquid into that of transparent vapor or gas.

10. Make the lid of a kettle air-tight, and permit the steam to issue from the pipe; a cloud is precipitated in all respects similar to that issuing from the funnel of the locomotive.

11. Permit the steam as it issues from the pipe to pass through the flame of a spirit-lamp, the cloud is instantly dissolved by the heat, and is not again precipitated. With a special boiler and a special nozzle the experiment may be made more striking, but not more instructive, than with the kettle.

12. Look to your bedroom windows when the weather is very cold outside; they sometimes stream with water derived from the condensation of the aqueous vapor from your own lungs. The windows of railway carriages in winter show this condensation in a striking manner. Pour cold water into a dry drinking-glass on a summer's day: the outside surface of the glass becomes instantly

dimmed by the precipitation of moisture. On a warm day you notice no vapor in front of your mouth, but on a cold day you form there a little cloud derived from the condensation of the aqueous vapor from the lungs.

13. You may notice in a ballroom that as long as the doors and windows are kept closed, and the room remains hot, the air remains clear, but when the doors or windows are opened a dimness is visible, caused by the precipitation to fog of the aqueous vapor of the ballroom. If the weather be intensely cold the entrance of fresh air may even cause snow to fall. This has been observed in Russian ballrooms; and also in the subterranean stables at Erzerum, when the doors are opened and the cold morning air is permitted to enter.

14. Even on the driest day this vapor is never absent from our atmosphere. The vapor diffused through the air of this room may be congealed to hoarfrost in your presence. This is done by filling a vessel with a mixture of pounded ice and salt, which is colder than the ice itself, and which, therefore, condenses and freezes the aqueous vapor. The surface of the vessel is finally coated with a frozen fur, so thick that it may be scraped away and formed into a snowball.

15. To produce the cloud, in the case of the locomotive and the kettle, heat is necessary. By heating the water we first convert it into steam, and then by chilling the steam we convert it into cloud. Is there any fire in nature which produces the clouds of our atmosphere? There is: the fire of the sun.

16. Thus, by tracing backward, without any break in the chain of occurrences, our river from its end to its real beginning, we come at length to the sun.

17. There are, however, rivers which have sources somewhat different from those just mentioned. They do not begin by dribblets on a hillside, nor can they be traced to a spring. Go, for example, to the mouth of the river Rhone, and trace it backwards to Lyons, where it turns to the east. Bending round by Chambéry, you come at length to the Lake of Geneva, from which the river rushes, and which you might be disposed to regard as

the source of the Rhone. But go to the head of the lake, and you find that the Rhone there enters it, that the lake is in fact a kind of expansion of the river. Follow this upwards; you find it joined by smaller rivers from the mountains right and left. Pass these, and push your journey higher still. You come at length to a huge mass of ice—the end of a glacier—which fills the Rhone valley, and from the bottom of the glacier the river rushes. In the glacier of the Rhone you thus find the source of the river Rhone.

18. But again we have not reached the real beginning of the river. You soon convince yourself that this earliest water of the Rhone is produced by the melting of the ice. You get upon the glacier and walk upwards along it. After a time the ice disappears and you come upon snow. If you are a competent mountaineer you may go to the very top of this great snow-field, and if you cross the top and descend at the other side you finally quit the snow, and get upon another glacier called the Trift, from the end of which rushes a river smaller than the Rhone.

19. You soon learn that the mountain snow feeds the glacier. By some means or other the snow is converted into ice. But whence comes the snow? Like the rain, it comes from the clouds, which, as before, can be traced to vapor raised by the sun. Without solar fire we could have no atmospheric vapor, without vapor no clouds, without clouds no snow, and without snow no glaciers. Curious then as the conclusion may be, the cold ice of the Alps has its origin in the heat of the sun.

THE WAVES OF LIGHT.

20. But what is the sun? We know its size and its weight. We also know that it is a globe of fire far hotter than any fire upon earth. But we now enter upon another inquiry. We have to learn definitely what is the meaning of solar light and solar heat; in what way they make themselves known to our senses; by what means they get from the sun to the earth, and how, when there, they produce the clouds of our atmosphere, and thus originate our rivers and our glaciers.

21. If in a dark room you close your eyes and press the eyelid with your finger nail, a circle of light will be seen opposite to the point pressed, while a sharp blow upon the eye produces the impression of a flash of light. There is a nerve specially devoted to the purposes of vision which comes from the brain to the back of the eye, and there divides into fine filaments, which are woven together to a kind of screen called the retina. The retina can be excited in various ways so as to produce the consciousness of light; it may, as we have seen, be excited by the rude mechanical action of a blow imparted to the eye.

22. There is no spontaneous creation of light by the healthy eye. To excite vision the retina must be affected by something coming from without. What is that something? In some way or other luminous bodies have the power of affecting the retina—but how?

23. It was long supposed that from such bodies issued, with inconceivable rapidity, an inconceivably fine matter which flew through space, passed through the pores supposed to exist in the humors of the eye, reached the retina behind, and by their shock against the retina aroused the sensation of light.

24. This theory, which was supported by the greatest men, among others by Sir Isaac Newton, was found competent to explain a great number of the phenomena of light, but it was not found competent to explain all the phenomena. As the skill and knowledge of experimenters increased, large classes of facts were revealed which could only be explained by assuming that light was produced, not by a fine matter flying through space and hitting the retina, but by the shock of minute waves against the retina.

25. Dip your finger into a basin of water, and cause it to quiver rapidly to and fro. From the point of disturbance issue small ripples which are carried forward by the water, and which finally strike the basin. Here, in the vibrating finger, you have a source of agitation; in the water you have a vehicle through which the finger's motion is transmitted, and you have finally the side of the basin which receives the shock of the little waves.

26. In like manner, according to the wave theory of light, you have a source of agitation in the vibrating atoms, or smallest particles, of the luminous body; you have a vehicle of transmission in the substance which is supposed to fill all space, and to be diffused through the humors of the eye; and finally, you have the retina, which receives the successive shocks of the waves. These shocks are supposed to produce the sensation of light.

27. We are here dealing, for the most part, with suppositions and assumptions merely. We have never seen the atoms of a luminous body, nor their motions. We have never seen the medium which transmits their motions, nor the waves of that medium. How, then, do we come to assume their existence?

28. Before such an idea could have taken any real root in the human mind, it must have been well disciplined and prepared by observations and calculations of ordinary wave-motion. It was necessary to know how both water-waves and sound-waves are formed and propagated. It was above all things necessary to know how waves, passing through the same medium, act upon each other. Thus disciplined, the mind was prepared to detect any resemblance presenting itself between the action of light and that of waves. Great classes of optical phenomena accordingly appeared which could be accounted for in the most complete and satisfactory manner by assuming them to be produced by waves, and which could not be otherwise accounted for. It is because of its competence to explain all the phenomena of light that the wave theory now receives universal acceptance on the part of scientific men.

Let me use an illustration. We infer from the flint implements recently found in such profusion all over England and in other countries, that they were produced by men, and also that the Pyramids of Egypt were built by men, because, as far as our experience goes, nothing but men could form such implements or build such Pyramids. In like manner, we infer from the phenomena of light the agency of waves, because, as far as our expe-

rience goes, no other agency could produce the phenomena.

THE WAVES OF HEAT WHICH PRODUCE THE VAPOR OF OUR
ATMOSPHERE AND MELT OUR GLACIERS.

29. Thus, in a general way, I have given you the conception and the grounds of the conception, which regards light as the product of wave-motion: but we must go farther than this, and follow the conception into some of its details. We have all seen the waves of water, and we know they are of different sizes—different in length and different in height. When, therefore, you are told that the atoms of the sun, and of almost all other luminous bodies, vibrate at different rates, and produce waves of different sizes, your experience of water-waves will enable you to form a tolerably clear notion of what is meant.

30. As observed above, we have never seen the light-waves, but we judge of their presence, their position, and their magnitude, by their effects. Their lengths have been thus determined, and found to vary from about 1-30,000 to 1-60,000 of an inch.

31. But besides those which produce light, the sun sends forth incessantly a multitude of waves which produce no light. The largest waves which the sun sends forth are of this non-luminous character, though they possess the highest heating power.

32. A common sunbeam contains waves of all kinds, but it is possible to sift or filter the beam so as to intercept all its light, and to allow its obscure heat to pass unimpeded. For substances have been discovered, which, while intensely opaque to the light-waves, are almost perfectly transparent to the others. On the other hand, it is possible, by the choice of proper substances, to intercept in a great degree the pure heat-waves, and to allow the pure light-waves free transmission. This last separation is, however, not so perfect as the first.

33. We shall learn presently how to detach the one class of waves from the other class, and to prove that waves competent to light a fire, fuse metal, or burn the hand like a hot solid, may exist in a perfectly dark place.

34. Supposing, then, that we withdraw, in the first instance, the large heat-waves, and allow the light-waves alone to pass. These may be concentrated by suitable lenses and sent into water without sensibly warming it. Let the light-waves now be withdrawn, and the larger heat-waves concentrated in the same manner; they may be caused to boil the water almost instantaneously.

35. This is the point to which I wished to lead you, and which without due preparation could not be understood. You now perceive the important part played by these large darkness-waves, if I may use the term, in the work of evaporation. When they plunge into seas, lakes, and rivers, they are intercepted close to the surface, and they heat the water at the surface, thus causing it to evaporate; the light-waves at the same time entering to great depths without sensibly heating the water through which they pass. Not only, therefore, is it the sun's fire which produces evaporation, but a particular constituent of that fire, the existence of which you probably were not aware of.

36. Further, it is these self-same lightless waves which, falling upon the glaciers of the Alps, melt the ice and produce all the rivers flowing from the glaciers; for I shall prove to you presently that the light-waves, even when concentrated to the uttermost, are unable to melt the most delicate hoarfrost; much less would they be able to produce the copious liquefaction observed upon the glaciers.

37. These large lightless waves of the sun, as well as the heat-waves issuing from non-luminous hot bodies, are frequently called obscure or invisible heat. We have here an example of the manner in which phenomena, apparently remote, are connected together in this wonderful system of things which we call Nature. You cannot study a snowflake profoundly without being led back by it step by step to the constitution of the sun. It is thus throughout Nature. All its parts are interdependent, and the study of any one part completely would really involve the study of all.

EXPERIMENTS TO PROVE THE FOREGOING STATEMENTS.

38. Heat issuing from any source not visibly red cannot be concentrated so as to produce the intense effects just referred to. To produce these it is necessary to employ the obscure heat of a body raised to the highest possible state of incandescence. The sun is such a body, and its dark heat is therefore suitable for experiments of this nature.

39. But in the atmosphere of London, and for experiments such as ours, the heat-waves emitted by coke raised to intense whiteness by a current of electricity are much more manageable than the sun's waves. The electric light has also the advantage that its dark radiation embraces a larger proportion of the total radiation than the dark heat of the sun. In fact, the force or energy, if I may use the term, of the dark waves of the electric light is fully seven times that of its light-waves. The electric light, therefore, shall be employed in our experimental demonstrations.

40. From this source a powerful beam is sent through the room, revealing its track by the motes floating in the air of the room; for were the motes entirely absent the beam would be unseen. It falls upon a concave mirror (a glass one silvered behind will answer) and is gathered up by the mirror into a cone of reflected rays; the luminous apex of the cone, which is the focus of the mirror, being about fifteen inches distant from its reflecting surface. Let us mark the focus accurately by a pointer.

41. And now let us place in the path of the beam a substance perfectly opaque to light. This substance is iodine dissolved in a liquid called bisulphide of carbon. The light at the focus instantly vanishes when the dark solution is introduced. But the solution is intensely transparent to the dark waves, and the focus of such waves remains in the air of the room after the light has been abolished. You may feel the heat of these waves with your hand; you may let them fall upon a thermometer, and thus prove their presence; or, best of all, you may cause them to produce a current of electricity, which

deflects a large magnetic needle. The magnitude of the deflection is a measure of the heat.

42. Our object now is, by the use of a more powerful lamp, and a better mirror (one silvered in front and with a shorter focal distance) to intensify the action here rendered so sensible. As before, the focus is rendered strikingly visible by the intense illumination of the dust particles. We will first filter the beam so as to intercept its dark-waves, and then permit the purely luminous waves to exert their utmost power on a small bundle of gun-cotton placed at the focus.

43. No effect whatever is produced. The gun-cotton might remain there for a week without ignition. Let us now permit the unfiltered beam to act upon the cotton. It is instantly dissipated in an explosive flash. This experiment proves that the light-waves are incompetent to explode the cotton, while the waves of the full beam are competent to do so; hence we may conclude that the dark-waves are the real agents in the explosion.

44. But this conclusion would be only probable; for it might be urged that the mixture of the dark-waves and the light-waves is necessary to produce the result. Let us then, by means of our opaque solution, isolate our dark-waves and converge them on the cotton. It explodes as before.

45. Hence it is the dark-waves, and they only, that are concerned in the ignition of the cotton.

46. At the same dark focus sheets of platinum are raised to vivid redness; zinc is burnt up; paper instantly blazes; magnesium wire is ignited; charcoal within a receiver containing oxygen is set burning; a diamond similarly placed is caused to glow like a star, being afterwards gradually dissipated. And all this while the air at the focus remains as cool as in any other part of the room.

47. To obtain the light-waves we employ a clear solution of alum in water; to obtain the dark-waves we employ the solution of iodine above referred to. But as before stated (32), the alum is not so perfect a filter as the iodine; for it transmits a portion of the obscure heat.

48. Though the light-waves here prove their incompetence to ignite gun-cotton, they are able to burn up black paper; or, indeed, to explode the cotton when it is blackened. The white cotton does not absorb the light, and without absorption we have no heating. The blackened cotton absorbs, is heated, and explodes.

49. Instead of a solution of alum, we will employ for our next experiment a cell of pure water, through which the light passes without sensible absorption. At the focus is placed a test-tube also containing water; the full force of the light being concentrated upon it. The water is not sensibly warmed by the concentrated waves. We now remove the cell of water; no change is visible in the beam, but the water contained in the test-tube now boils.

50. The light-waves being thus proved ineffectual, and the full beam effectual, we may infer that it is the dark-waves that do the work of heating. But we clinch our inference by employing our opaque iodine filter. Placing it on the path of the beam, the light is entirely stopped, but the water boils exactly as it did when the full beam fell upon it.

51. The truth of the statement made in paragraph (34) is thus demonstrated.

52. And now with regard to the melting of ice. On the surface of a flask containing a freezing mixture we obtain a thick fur of hoarfrost (Paragraph 14). Sending the beam through a water-cell, its luminous waves are concentrated upon the surface of the flask. Not a spicula of the frost is dissolved. We now remove the water-cell, and in a moment a patch of the frozen fur as large as half-a-crown is melted. Hence, inasmuch as the full beam produces this effect, and the luminous part of the beam does not produce it, we fix upon the dark portion the melting of the frost.

53. As before, we clinch this inference by concentrating the dark-waves alone upon the flask. The frost is dissipated exactly as it was by the full beam.

54. These effects are rendered strikingly visible by darkening with ink the freezing mixture within the flask.

When the hoarfrost is removed, the blackness of the surface from which it has been melted comes out in strong contrast with the adjacent snowy whiteness. When the flask itself, instead of the freezing mixture, is blackened, the purely luminous waves being absorbed by the glass, warm it; the glass reacts upon the frost, and melts it. Hence the wisdom of darkening, instead of the flask itself, the mixture within the flask.

55. This experiment proves to demonstration the statement in paragraph (36); that it is the dark-waves of the sun that melt the mountain snow and ice, and originate all the rivers derived from glaciers.

There are writers who seem to regard science as an aggregate of facts, and hence doubt its efficacy as an exercise of the reasoning powers. But all that I have here taught you is the result of reason, taking its stand, however, upon the sure basis of observation and experiment.

THE WONDERS OF THE INFINITE

OUR PLANET AND ITS RELATION TO THE UNIVERSE

BY

P. A. PRICE

WHETHER man was given a beginning in a Mesopotamian Eden, or awoke to intelligence in some cradling valley of Central Asia, his first impression of external things no doubt concerned itself with conjectures regarding the sun, moon, and stars.

In this age we take, as a matter of course, the endless procession of days and nights, the seasons, the various stages of the moon, and too seldom indeed is our gaze directed towards the starry heavens. A little reflection on these things will prove wonderfully refreshing to the mind ordinarily intent upon business cares, and no other study costs so little or repays the student so well.

In the annals of every race, no matter how primitive it may be, are found references to the heavenly bodies. Religions of the past wrote the stories of their gods and goddesses into the star groups, or constellations, and the names these groups bear have immortalized deities and heroes who were as real to the people of the past as Washington, Franklin, Lincoln, and Lee are to us of the present day.

The earth we dwell upon is a body of spherical shape and swings about the sun, describing not quite a true circle in its path, or orbit. The earth is about 8,000 miles in diameter, and, owing to the fact that its path about the sun is not a true circle, its distance from that luminary will vary to some extent at different times of the year.

In the summer months we are about 92,450,000 miles away from the sun, and in the winter we are about 3,000,000 miles closer. At first glance it would seem that our winter months should be warmer on this account, and the reason they are not, so far as the Northern Hemisphere is concerned, is interesting.

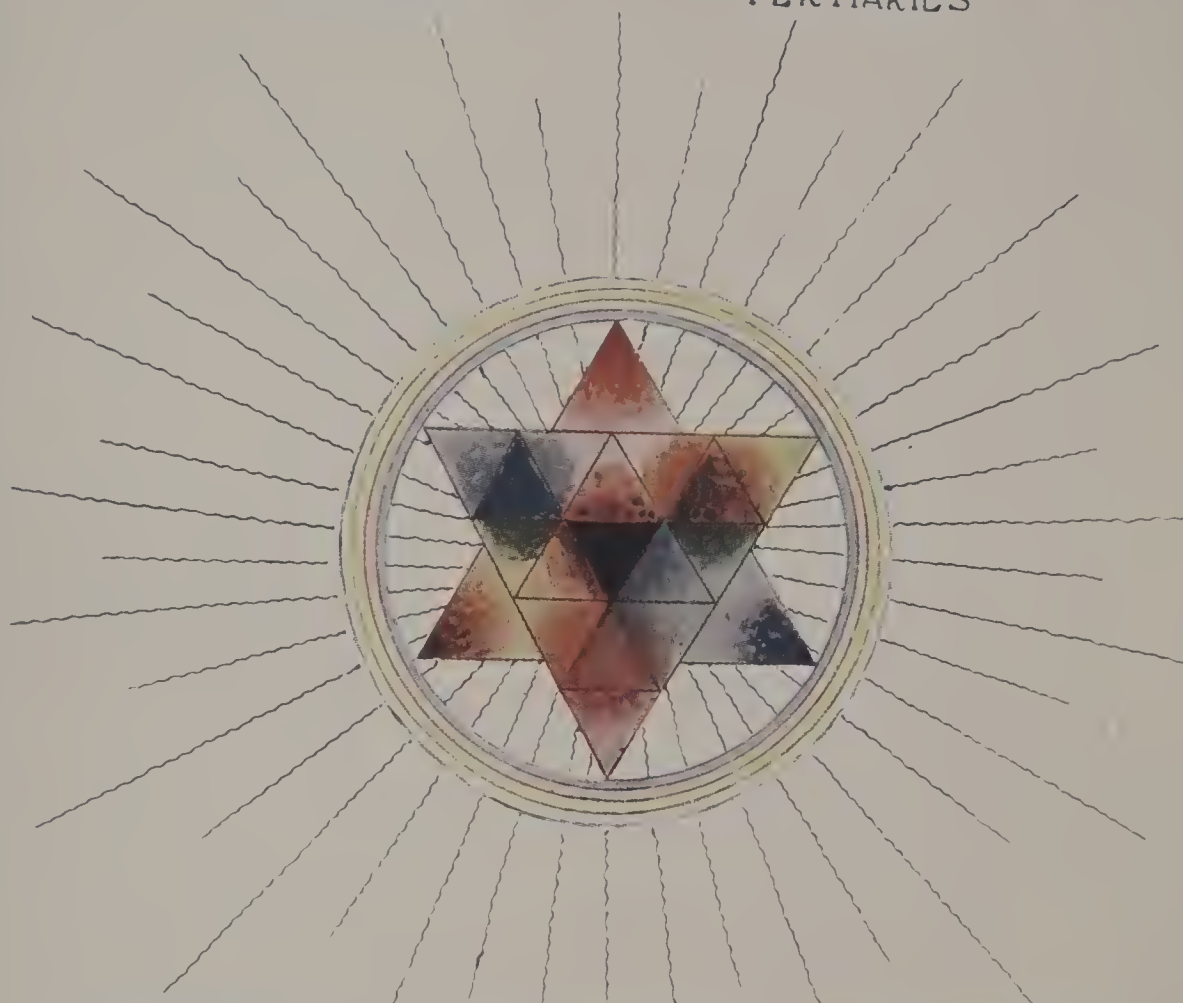
Imagine, if you can, a line drawn from the center of the sun to the center of the earth. Instead of entering the surface of the earth at the Equator—that imaginary

circle which divides the earth into two hemispheres, North and South—this line from the sun will enter the earth at a point $23\frac{1}{2}$ degrees north or south of the Equator, depending upon the location of the earth in its orbit, though it will coincide with the Equator for a few days twice a year, at the time of the Equinoxes—that is, at those times when the nights and the days are of equal length.

This indicates that the earth must be “tipped,” or is leaning either away or towards the sun, so far as the North Pole is concerned, else the line would always enter the earth’s surface at the Equator. And this is a fact. It happens that when the earth, as a whole, is nearest the sun, in the month of January, the North Pole of the earth is leaning away from the sun, and the waves of radiant energy sent out by the sun do not fall direct upon the Northern Hemisphere, but on an angle, or “slant,” and as a glancing blow is never as efficacious as one that is delivered direct, these waves do not have the same heating effect. And furthermore, the sun being so far to the south makes the days short and the nights long, and the little heat that is received cannot be “stored up” as it is through the long days and short nights of the summer season.

In the Southern Hemisphere, at this same time of the year, the South Pole of the earth is presented to the sun, and the southern continents of South America, Africa, and Australia have their summer season, with long days and short nights. Six months later, when the earth is at its farthest distance from the sun, the North Pole of the earth is leaning towards the sun, and the waves of radiant energy fall directly upon the Northern Hemisphere, to give a summer season to those who dwell in North America, Europe, and the greater part of Asia.

From the foregoing it must not be considered that the polar axis of the earth changes its direction to make the earth lean away or towards the sun; it is that the sun is at a relatively fixed point, and the earth, in its orbit, always directs its polar axis to what we call the Pole Star, just as the reader might walk about a table lamp, carry-



The Colors of the Spectrum

ing a cane which would be always pointed up and down at a certain angle towards the north and south, no matter in what direction he might be moving about the room.

The polar axis, it is true, does shift its general direction to some extent, but to a very small extent in comparison with the diameter of the orbit of the earth. The path of the earth about the sun might be considered in the same light as a weight attached to the end of a cord and swung rapidly with a circular motion. The cord which holds the earth in its orbit is that force called "gravitation," and it tends to draw the earth towards the sun just as the earth draws the article which you drop from your hands. Going back to the weight swung above your head by a restraining cord, the moment your hold upon the cord is released the weight shoots off through the air on a straight line, trailing the cord behind it. So with the sun and the earth. The force generated by the earth in its swing about the sun gives the earth a tendency to overcome the gravitational pull of the latter, and this keeps it from being drawn bodily into the fiery mass which constitutes the orb of day.

As the earth swings about the sun it always turns upon its axis once every twenty-four hours, with a speed at the Equator of 1,050 miles per hour. Thus it is that we have nights and days, depending on whether the place we live in is away from or towards the sun. When the people of New York are having their noon, it is midnight at that point which is exactly on the opposite side of the earth, for it is at that time away from the sun. And as the earth turns from west to east at the equatorial rate of 1,050 miles an hour, it will not be noon in Chicago till an hour later than in New York, and in Denver it will be two hours later, and in San Francisco three hours later. The hour of noon is determined at Washington, D. C., by certain calculations, and all points west of Washington will have their noon one, two, or three hours later, and points east of Washington will have their noon hour one hour earlier for each one thousand miles of distance. This applies to the United States.

In consequence of this difference in time for different

parts of the United States, a person traveling from New York to San Francisco will find his New York time to be three hours fast in San Francisco, and if he were traveling in the opposite direction his San Francisco time would be three hours slow when he reached New York. And if he traveled the whole way around the world he would either lose or gain a whole day of twenty-four hours, depending upon his direction of travel.

If it would be possible to take a trip to the sun by railroad train, traveling at the rate of 1,000 miles each day, we would be $254 \frac{1}{3}$ years upon our journey, and would find an immense globe with a diameter of 866,500 miles, or about $109\frac{1}{2}$ times that of the earth, and with a surface area of 12,000 times that of the earth. It is so hot that if this immense surface could be covered with a layer of ice 64 feet thick the ice would be melted in one minute's time. A still better idea of the intensity of the sun's heat may be obtained from the fact that such substances as carbon, and iron, copper, and other metals, subjected to it, are not only melted, but are in gaseous form. In other words, these substances have passed the molten condition and are in the same state as a drop of water becomes upon a red-hot stove, not alone changed to steam, but the steam in turn changed to gas. And in the sun's case this gas is heated to such a degree as to produce blinding light. It is really too hot to burn. All the combustible parts of it are gone, but it still exists in a state which is extremely hard to describe.

The surface of the sun is in a constant state of ebullition, or boiling, and great jets of this incandescent gas are thrown up to enormous heights, as much as 80,000 or 100,000 miles above the surface. At this height the gases become condensed to some extent, and in this state they prove themselves to be vapors of the various metals which exist upon the earth. Their nature is determined by an instrument known as the "spectroscope," which came into use in the year 1860.

WHAT THE SPECTROSCOPE REVEALS

The spectroscope consists of a tube so arranged that an entering ray of light is carried through one or more

prisms, or small, triangular pieces of glass. By these prisms the light rays are broken up into the colors of the rainbow, and by examining this rainbow effect by means of a magnifying lens the colors are seen to be crossed with dark lines. This array of colors is designated as a "spectrum."

When comparisons are made between the spectrum of the sun and that obtained by burning various metals, the same lines appear in certain colors of each. For example, certain lines are produced if iron is present in a flame, and as identical lines are found in certain colors of the solar, or sun's, spectrum, it is perfectly justifiable to believe that iron exists in the sun.

About forty of the elements found on earth are thus determined to be constituents of the sun, though in the form of fiery vapor. It is not unlikely that these vapors of the sun contain many other earthly elements in another form, a form which would produce these elements under conditions of lower temperature. No one would recognize the principal constituent of a diamond in the black soot of a tallow candle, or in the lump of sugar dropped in the morning cup of coffee, and yet, under another condition of formation, the carbon of the soot or of the sugar would have been a diamond.

All the deductions of science point to the conclusion that the sun was at one time immeasurably larger than it is now, reaching out beyond the orbit of the farthest planet, Neptune. This planet is 2,800 million miles from the sun, and therefore the sun's diameter then must have been more than 5,600 million miles.

At that time, however, the sun was not as it is now. Instead of being a fiery mass its substance was a thousand times thinner than the air we breathe. But the substance was active; it was permeated with a force which the theologian calls the power of God, and which the man of science calls energy. As a leaven of yeast this force caused movement in this elemental substance, and the corpuscles thereof—which were probably no more or less than electrical impulses—were drawn to and repelled from each other, in whorls and spirals, until

they united to form a substance still thinner than air, but almost solid in comparison with its former state.

ORIGIN OF THE PLANETS

Millions upon millions of years passed, and the substance grew more dense and drew in upon itself. The corpuscles vibrated in waves of certain length to produce light and heat, which in turn gave rise to other effects. Then came a time when the substance of the sun became almost as thick as water—it is but little more so now—and its speed of rotation, a natural effect of the whirling, swirling motion of its substance, became so great that immense drops of the fiery liquid were thrown off the parent body like water from a wagon-wheel.

These masses were rough and irregular in shape, but as they whirled in space, ever held by the long arm of gravitation to the parent sun, they took on spherical shape like clay upon the potter's whirling table, and they also commenced to cool. Before becoming solid, however, they in turn threw off masses of their substance which became "moons," and our moon was thus at one time a part of this world.

Just as a large substance will retain its heat longer than a smaller one, so our earth was a globe of fire for millions of years, and even now, though a thick crust has formed and hardened like slag from a furnace, and the waters of the rivers and oceans cover a large part of its surface—even now the interior of the earth is a fiery mass which bursts forth from time to time in volcanic eruptions.

The moon, however, with a diameter of one-fourth of that of the earth, became cold and lifeless long, long ago. But it is bound to the earth even as the earth is bound to the sun, and the force imparted to it on that day when it was flung 240,000 miles into space causes it to swing about the earth even as the earth swings about the sun. In the space between the suns of the heavens an object once set in motion will continue in motion until acted upon by another force. This is true on earth; it is true everywhere, but on the earth the gravitational effect of



HOW AN ECLIPSE IS CAUSED. SHOWING THE MOON BETWEEN THE EARTH AND THE SUN

the earth will bring a moving object to rest in a very short time.

The moon's speed of rotation has slowed down, and for that reason it always presents the same face to us. As it circles about the earth in a cycle of twenty-eight days, at certain times it gets between the earth and the sun in such a manner that the sun's rays fall upon the side not visible to us.) As no light except reflected sunlight comes to us from the moon, we cannot see the moon at these times, and it is said to be "dark."

As it proceeds in its orbit it emerges from this position with relation to the sun, and a portion of the surface towards the earth is illuminated by the sunlight. It is then we see the crescent of the "new" moon. Later on the angle widens, and finally, when it is what might be termed "back" of the earth, and the sun shines full upon the surface presented to us, we have the "full" moon. Still later it gets into position between the earth and the sun so that the reflected light is diminished, and it passes into the "dark" stage again.

ECLIPSES OF THE SUN AND OF THE MOON

Sometimes the sun, moon, and earth get into such relation to each other that there is what is called an "eclipse." If the moon gets between the earth and the sun in proper position there is an eclipse of the sun. If the earth gets between the sun and the moon there is an eclipse of the moon. In either event it is merely a case of an obstruction in the sun's light, just as your hand might be placed before a lamp in a hallway and thus throw the lighted area into darkness.

THE TIDES

The moon, in addition to giving light through the night, has an effect upon large bodies of water on the earth's surface, notably upon the oceans. Just as the sun pulls the earth, and the earth in turn pulls the moon, so the moon pulls upon that portion of the earth which is unstable. As a matter of fact, it draws upon all the earth, but the only appreciable effect of this influence is upon the oceans, wherein it causes "tides" by lifting up

the waters. This lift, in itself, does not amount to a very great deal, but just as a snowball builds itself up by rolling over snow-covered ground, so the tides build themselves up as they sweep towards the shores from far out at sea. At certain seasons of the year the sun and the moon pull together, and the result is a much higher tide than that caused by the moon acting alone.

OUR PLANETARY SYSTEM

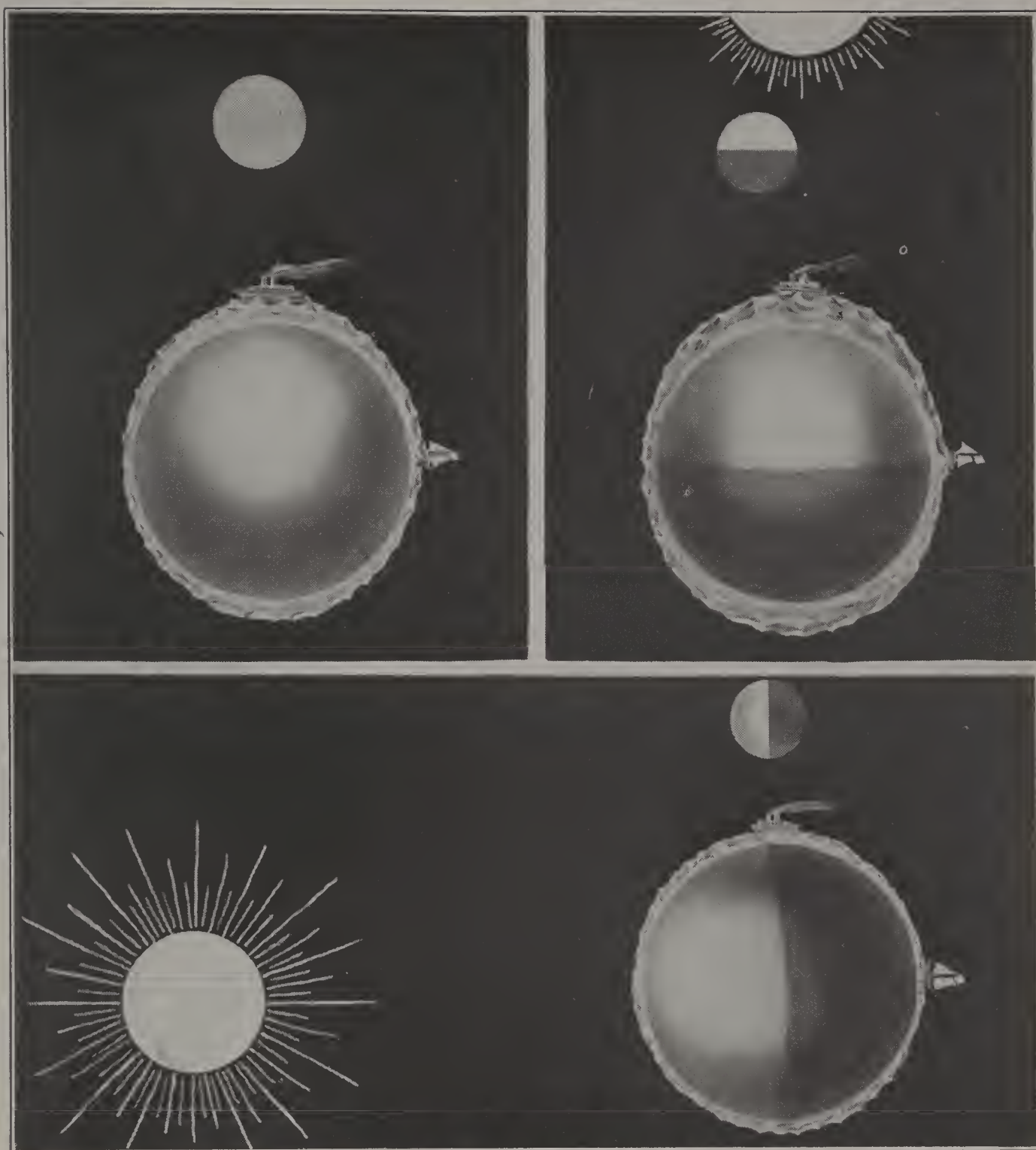
We have referred to the earth as being a mass thrown off from the parent body of the sun, but it was not the only mass thrown off. Between the earth and the sun are the orbits of two planets, Mercury and Venus, and beyond the earth are the orbits of Mars, Jupiter, Saturn, Uranus, and Neptune, in respective order of distance from the sun.

The name "planet" was given to these bodies by the Greeks, the word signifying "a wanderer," for it was noted by the ancients that these bodies were different from the stars, which seemed to be of permanent location. The ancients were right in this respect, for the planets are all members of the sun's family, and might be termed brothers and sisters of the earth, for they have the same parent, the sun, as a source of being.

Some data regarding this family group may be interesting. They are taken from Young's "Elements of Astronomy":

Name of planet	Diameter in miles	Distance from the sun in millions of miles	Years to complete orbit about the sun	One pound on the earth would weigh
Mercury	3,030	36.0 million	0.24 years	0.43 pounds
Venus	7,700	67.2 "	0.62 "	0.82 "
Earth	7,917.6	92.9 "	1.00 "	1.00 "
Mars	4,320	141.5 "	1.88 "	0.38 "
Jupiter	86,500	483.3 "	11.86 "	2.65 "
Saturn	73,000	886.0 "	29.46 "	1.18 "
Uranus	31,000	1781.9 "	84.02 "	0.90 "
Neptune	34,800	2791.6 "	164.78 "	0.89 "

It will be seen from this table that the earth is not a very big member of the family, as there are others very much larger. But the earth is the only one—as far as we know—that is in a condition to support life in the various forms that we know of. If man existed on Jupi-



THE TIDES

The first picture shows how the moon attracts the earth's water on the side nearest to it, causing a high tide there; on the other side the earth is drawn away from the water, leaving a high tide. The second picture shows the sun doing its part, although it is less powerful than the moon. Very high tides, or what are called spring tides, are caused by both the sun and the moon pulling the same way. The third picture shows the moon pulling one way and the sun the other way, and the result is the tides are not so strong as at other times.

ter, for example, he would be on an immense globe that has not yet cooled off and is still in a semi-molten condition, and his physical being would have to be entirely different from what it is on this earth. If he weighed 150 pounds here he would weigh 397.5 pounds there, and his year would comprise almost twelve of ours.

Mercury and Venus are both smaller than the earth, and have no doubt cooled off sufficiently to support a form of life similar to that of this earth, but they are so close to the sun that unless atmospheric conditions are different from what they are here the inhabitants would be exposed to intolerable heat. Mercury has almost four years while we are having one, and a person weighing 150 pounds on this earth would only weigh 64.5 pounds on that planet.

AS TO LIFE ON THE PLANETS

There is much talk of the possibility of life on the planet Mars, due in great part to the peculiar markings on the surface when studied with a powerful telescope. There is also some telescopic evidence of atmospheric conditions being similar to those of this world, but science is far from being willing to state that life exists as we have life here.

The length of time required for a planet to complete its orbit or path about the sun is of course dependent upon its distance from the sun. We have seen that the earth takes one year, or rather a period of time which we call one "year." The speed of travel in the orbit is also another factor; in the case of the earth it amounts to eighteen miles per second in its journey about the sun.

From the table it will be noted that Uranus is over 82 years in making its journey, and far-off Neptune is almost 165 years on its ceaseless round. Uranus may be seen with the unaided eye as a very faint star, but Neptune requires at least an opera glass to be made visible. Both these planets have a greenish tint, so far as color is concerned. Mars is red, as is Saturn, and Jupiter, Mercury, and Venus are bright in color.

Saturn is interesting on account of its "rings," which

are whorls of gaseous matter surrounding the planet. Saturn has ten moons in addition to its rings. Jupiter has seven; Uranus has four; Mars, two; and the earth and Neptune, one moon each. One of Jupiter's moons is about 3,600 miles in diameter, and the others are about the size of ours. Both of the moons of Mars are very small.

In the space between Mars and Jupiter there are several hundred bodies revolving about the sun, just as a planet might revolve, though they are widely scattered. Opinions differ as to their origin, though it is believed by some astronomers that they are the fragments of a disrupted planet which either exploded or was struck by a meteor, one of those wanderers from space which are called "shooting stars." None of them are very large, the majority being masses of rock twenty or thirty miles in diameter. It has been computed that the total bulk of these "asteroids," as they are called, amounts to less than one-hundredth part of the bulk of the earth.

WHAT THE STARS REALLY ARE

So far we have confined our attention to our immediate neighbors in the heavens, and while the sun, moon, planets, and their satellites are of prime importance in our affairs, some of course to a less extent than others, the whole solar system is very insignificant in comparison with other objects in the heavens.

On a clear night, when the moon is dark, the heavens glitter from zenith to horizon with thousands upon thousands of stars, and of them we will attempt to give a general description.

The people of ancient times had only the most remote idea of what the stars really are, though there are a few exceptions. Hipparchus, a Greek astronomer, who lived about 200 B. C., sensed the fact that what we call stars are suns like our sun, but so far away that they appear merely as points of light. It is also likely that the Egyptians had a very good conception of the stars. All manner of ingenious ideas were entertained by the majority of people to explain the evening skies' spangled draperies.

It was noticed at a very early date, probably in prehistoric times, that the sun seemed to travel in a regular path among the stars. As a matter of fact the sun does not travel among the stars to an extent that is appreciable except from the most complicated of observations. What actually happens is this: the earth in its orbit about the sun is, at different times of the year, between the sun and certain stars, if the word "between" may be used in this sense, and from month to month the stars of the evening sky seem to change, some dropping out of sight and others coming into view.

If the sun's light were blotted out for twenty-four hours, so there would be no daylight for that time, we would see all the stars of the heavens pass above us in a stately procession. As it is, we see certain stars this month, and as the stars do not keep time in their appearance with the setting of the sun, but gain four minutes each night, the stars we see this month pass into the west and a new group comes into our view. Those we see tonight are invisible to that half of the world wherein it is day, and when our part of the world comes again into the sun's light the stars are invisible to us, but visible in the night sky of the other half of the world.

For greater ease of expression it is customary to speak of the sun's "path among the stars," and for the sake of convenience we will refer to this path in speaking of the various star groups, or constellations. Pre-eminent among these groups are the "Signs of the Zodiac," a belt of constellations which marks the progress of the earth from month to month in its orbit about the sun.

THE SIGNS OF THE ZODIAC

The Zodiac may be considered as the numerals marking the hours on the dial of a timepiece, with the earth represented by the hour hand, and the sun by the pivot at the center of the dial. The center is fixed, but the hour hand moves from one numeral to another, and is thus between the sun and the "signs" as represented by the numerals.

There are twelve of these "signs" in the Zodiac, each

covering 30 degrees of the 360 of the complete circle, and as the majority of them represent animals or animate creatures, the name of "Zodiac," or "Zone of Animals," was given to this belt by the ancients.

Though the majority of the names have descended to us from prehistoric times, they are still used by astronomers. They are considered, however, in a very different relation to the earth from the relation they once occupied. When astrology, the "parent of astronomy," was a flourishing "science," it was considered that people born at certain times of the year were gifted in some particular way, or were subject to this or that weakness, or tendencies to certain organic troubles. Even today, in almanacs distributed by patent-medicine concerns, the signs of the Zodiac are seen encircling the human body, with arrows pointing to various organs or parts which are liable to affliction as a result of these "influences." It may be that people born at certain times of the year, or during certain years, have a predisposition towards one thing or another, but most assuredly the stars have nothing to do with it. One could as well say that a railroad wreck was caused by a school-house because a school-house happened to be located near the scene of the wreck.

At a time when astronomy came to be studied in a more or less scientific manner—and this was many thousands of years ago—it was noticed that during the month marking the advent of Spring, or the Vernal Equinox, the sun always seemed to be in a certain constellation, and this constellation was given the name of Aries (the ram). A month later the sun seemed to be in another star-group, which was called Taurus (the bull), and so on through the entire twelve.

The names of these twelve constellations, and the symbols which have represented them from the most ancient times, are as follows:

Spring	{	Aries	The Ram	♈	Autumn	{	Libra	The Balance	♎
		Taurus	The Bull	♉			Scorpio	The Scorpion	♏
		Gemini	The Twins	♊			Sagittarius	The Bowman	♐
Summer	{	Cancer	The Crab	♋	Winter	{	Capricornus	The Goat	♑
		Leo	The Lion	♌			Aquarius	The Waterman	♒
		Virgo	The Virgin	♍			Pisces	The Fishes	♓



THE HEAVENS AT NIGHT

It would be impossible to convey on the largest sheet that could be printed on the largest press in the world, even an approximate idea of the comparative sizes of the heavenly bodies and their distances from us and from one another. In the above drawing the artist, however, using as a background the heavens as they appear to the eye at night, with the Milky Way and many of the Constellations, shows also the planets of our own solar system as they are revealed by powerful telescopes.

No explanation has ever been given that is entirely satisfactory to explain the names employed for these star groups. A few may be explained as follows: When the sun reaches the constellation known as Cancer, it starts “back” to the south, and this retrograde motion may have suggested the locomotion of a crab. In the same manner the sun, upon reaching the “sign” of Capricornus, commences to “climb” to the north, as a goat climbs a hill upon which it is grazing. Libra (the balance) may have marked the location of the sun when the days and nights are of equal length.

THE CONSTELLATIONS

With very few exceptions the outlines of the constellations, as marked by the stars of each group, give no clue to the origin of the groups, but by aid of star maps or an atlas it is not difficult to locate the majority of them. Some of the groups are made up of a great number of bright stars, and others are outlined with such faint stars that it requires a great deal of patience to place them. As it is, the stars themselves are of greatest interest to the scientist, and the constellations only serve in a general way as an aid in finding them.

The most prominent stars of the northern skies are:

PRINCIPAL STARS VISIBLE IN THE NORTHERN HEMISPHERE

Name	Distance in light years	In constella- tion	Part of heavens	Month	Brilliance; Sun = 1'
Sirius	8	Canis Major	South	February	40 times
Arcturus ...	50	Boötes	Overhead	June	6200 “
Rigel		Orion	Overhead	January	
Capella	29	Auriga	Overhead	January	270 “
Vega	20	Lyra	Overhead	August	2050 “
Procyon ...	12	Canis Minor	South	December	
Betelgeuse ..		Orion	South	January	
Aldebaran ..	27	*Taurus	Overhead	January	70 “
Antares		*Scorpio	South	July	
Altair	16	Aquila	Overhead	September	25 “
Spica		*Virgo	South	May	
Fomalhaut..		Pisces Australis	South	October	
Pollux	50	*Gemini	Overhead	March	170 “
Regulus	32	*Leo	Overhead	April	110 “
Deneb		Cygnus	Overhead	September	
Castor		*Gemini	Overhead	March	
Polaris (Pole Star)	47	Ursa Minor	North	All the year	190 “

*Indicates zodiacal constellation.

As with the constellations, the names of the stars have come down to us from ancient times, and, as previously noted, they bear the names of deities and heroes of the people of those times. It was a wonderful way to immortalize these names, preserved as they are in the firmament.

The reader will note, in the heading of the table, the term “light years” used as a unit to measure a star’s distance from the earth. To give an idea of what this represents, the following analogy will be used: In watching a railroad train from the distance of a mile or more it will be noted that the steam from the whistle is seen several seconds before the sound of the whistle is heard. This is because it takes—at sea level—about one second for sound to travel 1,100 feet. If the train is a mile away the sound of the whistle will be about five seconds in reaching the ear. It also takes a certain length of time for light to travel from its source to the observer, though it travels at the almost incredible speed of 186,000 miles per second. Even at this speed the light from the sun is over eight minutes in reaching the earth.

A “light year” represents the distance that a ray of light will travel in one year’s time, at the rate of 186,000 miles per second, and is numerically expressed as follows:

186,000.....	miles per second
11,160,000.....	miles per minute
669,600,000.....	miles per hour
16,070,400,000.....	miles per day
5,865,696,000,000.....	miles per year

The star nearest the earth, and which is too far to the south to be seen from the United States, is four and a half light years, or some twenty-six trillion miles away, and Sirius, the bright star of the constellation Canis Major, which may be seen in the southern sky in the evenings of February, is over eight light years distant. These stars are close at hand, in comparison with those for which no distance has been determined, and which are possibly as much as 20,000 or 30,000 light years distant from the planet on which we live.

NO LIMITS TO ETERNAL SPACE

The reader must bear in mind that space is infinite. No matter how far away you may go from the earth, you may continue to go that much farther, and again that much farther. Space can have no limiting lines, for once a boundary is thought of the mind instinctively considers: What is beyond this boundary? So with eternity: one cannot imagine when time started, for that implies a preceding period which must be accounted for.

We have spoken of the possible origin of the sun from a very thin, gaseous elemental substance, and there is every reason to believe that all the stars originated in the same manner; for just as our sun is a star, though a small one, so all the stars are suns. As their substance is revealed by the spectroscope to be similar in nature to our sun, it is conceivable that they have a similar beginning. What the elemental substance may be we do not know, though science, as stated before, is inclined to believe it may be electric waves.

THE INVENTION OF THE TELESCOPE

While there has always been much ingenious speculation about the stars, practically nothing was known of them until after the invention of the telescope. There is a story to the effect that an optician in Holland made the first instrument, and it is known that a man named Lippershey applied for a patent upon such an instrument in 1608. Credit for the invention of the telescope is usually given to Galileo, who heard about the instrument made in Holland and developed one for himself in May, 1609.

Galileo's first telescope had a magnifying power of but three, but he soon improved upon this and made an instrument which magnified thirty times, and with it discovered the moons of Jupiter, and also identified the peculiar shadows on our moon as mountains. Glass-workers then became interested in the subject, and better lenses were made.

In 1611 Kepler made substantial improvements in the instrument. The great trouble with the early telescopes

was their size, which was necessary on account of the many imperfections of lenses, etc. A scientist named Huygens made an instrument 300 feet long, and in spite of this unwieldy length he arranged it so that very satisfactory results were obtained.

It was not until the nineteenth century that satisfactory object glasses and lenses were made, the great trouble being the production of flawless pieces of glass, which are necessary for this purpose. The first telescope was made on the plan of an opera glass, or spy glass, but with the development of the science and the discovery of certain laws of optics the "reflecting" type came into being, which is now the type most generally used.

In this form of instrument the observed object is reflected from a large concave mirror so arranged as to throw the reflected object upon a smaller mirror. This, in turn, directs the image to the eye through a magnifying lens.

The smallest star which it is possible to see with the unaided eye is what is known as a "sixth-magnitude" star. Vega, in the constellation Lyra, is of first magnitude; Polaris, the Pole Star, is of second; Megrez, marking the jointure of the handle and the bowl of the "Big Dipper," is of third; the three stars of Lyra nearest to Vega are of fourth; and the other visible stars in the heavens which are more faint are examples of fifth and sixth magnitude.

The magnitude of a star is not always a question of actual size, for the star may be so far away as to be almost imperceptible and yet be truly immense. This is not a hard and fast rule, for some of the first-magnitude stars are so far away that no idea can be obtained of their distance, even in light years. Such a case is that of Spica, the bright star in the zodiacal constellation Virgo (the virgin).

All the stars have a motion in space, some in the general direction of the earth, and others in the opposite direction. The sun is traveling in the direction of Vega, carrying the earth and the other planets with him at a speed of about twelve and one-half miles per second. If



IMMEASURABLE SPACE

In drawing this picture, our artist tried to help us understand the wonderful size of the universe and the immeasurable distances in space. The airplane is the fastest means of travel that has as yet been invented, and these airplanes, traveling at the rate of 150 miles per hour, or two and one-half miles per minute, would take 69 years to reach the sun. It would take 16 million years to reach the nearest star. The figures on each airplane show how long it would take to reach the various planets to which they point.

a star seems to "shift" its location when observed from the opposite ends of the earth's orbit, and the apparent "shift" can be determined as a definite distance, it is possible to gain a general idea of the star's distance from the earth. Other methods are also used, and these, while extremely complicated, present no great difficulties to the mathematician if certain facts are known.

REVELATIONS OF THE LENS

The telescope has brought before us many wonderful objects, not the least of which are the "nebulae," filmy, lacelike wisps of substance which can only be compared to fragments of a cloud, and yet in many cases they are so large that our entire solar system could be completely lost in their depths.

The Pleiades, or "Little Dipper," seems to be enmeshed in a nebula, and another nebula, visible on a dark night, may be observed in the sword handle of "Orion," just below the three stars which form the belt of the constellation.

The wonderful "Milky Way" is made up largely of nebulous clusters, which in a measure accounts for the pale luminescence marking its path across the heavens.

Not far to the east of Vega, and in the constellation Hercules, is what is known as a "star cluster," containing over six thousand suns, all enmeshed in a nebula. Each of these suns may be much larger than our sun, but the distance is so remote from us that only a high-power telescope can distinguish anything but a not overly brilliant single star.

Truly the heavens are full of wonders far exceeding anything upon this earth, though we in turn are a part of it all.

There are stars of almost every color, and of every age, from those new-born, like the brilliant star which came into the eastern heavens early in June of 1918, to those which are dead and dark and are only evident by the effect they have upon their companions.

Such dead stars wander through space, and sometimes collide with other stars. Then there is a tremendous explosion, and the heat developed burns the fragments

of the two stars into gas, which may form a nebula which, in turn, may develop into a new star. With infinity as the scene of action and an eternity setting no limits of time, anything and everything may take place, and as a matter of fact this is precisely what does take place.

On a summer evening we often notice what we call "falling" or "shooting" stars. Thousands of them fall daily upon the surface of the earth and sea, but most of them are burnt up before they reach our planet. Their origin is unknown, but they may be fragments of exploded suns previously referred to, thrown so far into space as to come within the influence of the earth's gravitation. Traveling at an incredible rate of speed, the friction they encounter in passing through the earth's atmosphere causes them to be heated to an intense degree, and unless they are very large they are entirely consumed. Meteorites, as they are called, have been found in many places throughout the earth, and all show indications of being subjected to great heat. They are largely composed of iron.

Other visitors from space are comets. They are the strangest and least understood of all the phenomena of the solar system, of which they seem to be a part. Astronomers believe them to be groups of meteoric substances, together with various gases which have been ejected from some solar volcano, and thrown so far into space as to have an orbit of their own. The "head" of the comet has been called "a gravel bank," consisting as it does of masses of small stones or iron ore, though, instead of being packed together, the particles may be miles apart. With this material are probably various gases, which form the comet's "tail," and so thin is this gas that the amount in a "tail" of one hundred thousand miles in length "might be carried in a suitcase," as some one has expressed it. What makes it look so formidable is that each and every particle of this "tail" has the property of reflecting light, just as a cloud has this property, and, from the enormous distance that we are from these celestial visitants, we see the total sum of the

reflections of each of these microscopic particles. If a comet should strike the atmosphere of the earth "head on," there would probably be an unusual display of "shooting stars," and that would be all there would be of it, but it would be the end of the comet itself.

SELF CULTURE QUESTIONS.

Volume VII.

By MARTIN GROVE BRUMBAUGH,

Professor of Pedagogy, University of Pennsylvania, 1895-1900; Superintendent of Public Instruction, Philadelphia, 1906-1915; Governor of Pennsylvania, 1915-1919;

1. What do you learn as to the effect of the Wonders of Nature upon the progress of Science? (p. 17.)
2. What is meant by the Precession of the Equinoxes? (p. 19.)
3. What do you know of the making of the Earth's Crust? (p. 24.)
4. Explain some of the mechanical, physical, and chemical processes of Earth Sculpturing. (pp. 27-43.)
5. What are some of the theories as to when coal measures were deposited? (p. 33.)
6. Why is nearly all the land of the Globe in the Northern Hemisphere? (p. 36.)
7. Why do the great peninsulas point to the South? (p. 36.)
8. What is a probable explanation of the Fjords of Norway, Scotland, Patagonia, etc.? (p. 38.)
9. Name some striking instances of Man's adaptability to climatic conditions. (p. 47.)
10. What are the leading things the Earth teaches as to the possibility of life in other worlds than ours? (pp. 43-57.)
11. What are some of the leading things that Geology teaches us as to the history of Man on the Earth? (pp. 51-60.)
12. How does Geology teach us the history of the Earth itself? (pp. 51-60.)
13. Name the two great classes of the Geological Strata. (p. 61.)
14. What are the five great Geological Periods? (p. 61.)
15. What do you understand by Prehistoric Archæology? (pp. 62-72.)
16. Name its four Great Epochs. (pp. 62-72.)
17. Give some of the earliest references to Iron, Gold, Copper, and Tin. (pp. 62-72.)
18. Describe some "finds" of articles belonging to the Iron Age. (p. 71.)
19. What inference may be drawn as to their age? (pp. 71-72.)
20. Describe some leading characteristic of varieties of mankind. (pp. 73-74.)

21. How do we learn that some of these have lasted for thousands of years? (p. 77.)
22. About how many distinct Known Languages are there on the earth? (p. 82.)
23. What has language to tell us of Man's age on the earth? Reply in your own words. (pp. 82-87.)
24. Name some of the oldest languages. (pp. 82-87.)
25. How does the growth of Culture or Civilization give us an idea of Man's age on the Earth? (pp. 88-107.)
26. What are the three great stages in the development of Human Life? (pp. 98-107.)
27. Compare this development with what is stated on pp. 51 to 72. Do the various writers in essentials agree? If not, wherein do they differ? (pp. 100-107.)
28. Which of the Continents contains the largest population? (p. 108.)
29. Which is the most numerous race on the Earth? (p. 108.)
30. Which is the most widely spoken language in the world? (p. 109.)
31. Name the chief races of mankind. (p. 109.) (See also pp. 73-108, and Question 20.)
32. Why are many of the strange Peoples of the world becoming less strange every year? (pp. 110-116.)
33. Name some of the things that Man has done to change the face of Nature. (p. 128.)
34. Describe an Avalanche and its effect. (pp. 131-134.)
35. What is the Mer de Glace? (pp. 135-144.)
36. What is the origin of the word Glacier? (pp. 135-144.)
37. What have you learned of the origin, progress, and future of Niagara Falls? (pp. 141-145.)
38. Where is Mount Shasta? (pp. 145-150.)
39. What are its general features? (pp. 145-150.)
40. What may be seen from its summit? (pp. 145-150.)
41. Name the chief eruptions of Vesuvius during the Christian Era. (pp. 150-162.)
42. What are Stalactites and Stalagmites? How and of what are they formed? (pp. 164-173.)
43. Where are some fine examples to be seen in America? (pp. 164-173.)
44. Where is the spot known as the World's End? Describe some of its features. (pp. 173-181.)
45. What is the Taj Mahal? Give three brief poetical phrases describing it. (pp. 181-186.)

46. Name some famous men of Greece and Rome associated with the Parthenon. (pp. 186-191.)
47. Write an account of the Parthenon. (pp. 186-191.) (Consult also an Encyclopedia.)
48. What are the two ways in which Plants and Animals leave their mark on the surface of the Earth? (pp. 217-228.)
49. Describe them broadly in your own words. (pp. 217-228.)
50. What are some of the ways in which plants obtain and utilize their food? (pp. 229-234.)
51. Describe the functions of a flower. (pp. 229-234.)
52. What is the highest development of vegetation? (pp. 229-234.)
53. What are the peculiar properties of the sand-box nut? (pp. 234-237.)
54. To what uses is the lace-plant put? (pp. 238-241.)
55. What are Teazels used for? (pp. 241-242.)
56. Describe the pitcher-plant. (pp. 243-244.)
57. Which plant did Charles Darwin describe as the most wonderful in the world? (pp. 244-245.)
58. Name some of the uses of the hop-plant. (pp. 245-248.)
59. Describe some of the ways in which plants travel. (pp. 251-255.)
60. Compare the action of the sand-box nut and the furze and broom-pods. (pp. 251-255.)
61. Where do the three groups of the American Forest lie? (pp. 255-276.)
62. What are the distinguishing peculiarities of each? (pp. 255-275.)
63. Where are the greatest number of species of trees to be found? (pp. 255-276.)
64. Where do we find most evergreens? (pp. 255-276.)
65. Describe how trees fight each other and struggle for existence. (pp. 255-276.)
66. State how species of trees become distributed. (pp. 255-276.)
67. Why should we preserve our Forests? (pp. 255-279.)
68. Give a description of some of our big trees, their names, and dimensions. (pp. 279-289.)
69. Where are they chiefly found? (pp. 279-289.)
70. Who were some of their first discoverers? (pp. 279-289.)
71. State the fundamental principles of plant-breeding. (pp. 289-300.)
72. What is meant by evolution and variation in plants? (pp. 289-300.)

73. Give some account of the achievements of Plant Breeding.
And Mr. Burbank's view of its possibilities. (pp. 289-300.)
74. Describe the "movement to music" of atoms as demonstrated
by Tyndall. (pp. 305-306.)
75. On the Earth's surface, which is the greater, land or water?
(pp. 307-328.)
76. Write a general description of the flow of the Ocean. (pp.
307-328.)
77. Describe the attraction of the Moon and Sun upon the Water
of the Ocean. (pp. 307-328.)
78. What is known of life and its conditions in Ocean depths?
(pp. 307-328.)
79. Which are the Rivers in the Sea, and what is their effect?
(pp. 307-328.)
80. What are Diatoms and Foraminifera? (pp. 329-337.)
81. What is known of Vegetable Life in the Ocean? (pp. 329-
337.)
82. What is the Oldest Picture Book of all? (pp. 338-356.)
83. Describe the origin of the signs of the Zodiac. (pp. 338-56.)
84. How is one able to determine just where the people lived who
first drew them? (pp. 338-357.)
85. What may be learned from this story of the Oldest Picture
Book of all? (pp. 356-357.)
86. With what terrestrial phenomena are the displays of the
Aurora Borealis connected? (pp. 357-366.)
87. What conclusion may be drawn from the observation of the
spectrum of the Aurora Borealis? (pp. 357-366.)
88. Has any connection between Sun Spots and Auroral Displays
been finally established? (pp. 357-366.)
89. How does Professor Tyndall prove from the study of Rivers
that every occurrence in Nature is the result of Cause and
Effect? (pp. 366-380.)
90. Trace some River from its mouth to its source step by step.
(pp. 368-380.)
91. Whence comes the Rain? (pp. 368-380.)
92. What are Clouds? (pp. 368-380.)
93. What part does the Glacier play in this chain of events?
(pp. 368-380.) (See also Questions 35 and 36.)
94. Explain the difference between light waves and heat waves.
(pp. 368-380.)
95. What effect then have the heat rays of the Sun in making
our rivers? (pp. 368-380.)

96. Describe some of the experiments by which the foregoing is proved. (pp. 368-380.)
97. Why is it colder in winter, although we are nearer the sun at that time, than in summer? (pp. 381-382.)
98. What forces keep the earth in its regular course around the sun and yet keep it from being drawn into the fiery mass from which we derive our light and warmth? (p. 385.)
99. What is the spectroscope and how can we, by its means, determine the elements of which the sun is formed? (pp. 386-387.)
100. How does modern science prove that the signs of the Zodiac can have no possible effect on human ailments or on human destiny? (p. 398.)
101. What is a light year and how many light years is the nearest star distant from the earth? (p. 402.)
102. Why can there be no limiting lines to space? (p. 403.)
103. Who invented the telescope, and how does the modern telescope differ from the early instruments? (pp. 403-404.)
104. What are nebulae? What are star clusters composed of, and how does our own solar system compare in size with groups of other heavenly bodies which appear to us like filmy wisps? (p. 407.)
105. What are "dead" stars, and what happens when they collide with other heavenly bodies? (p. 407.)
106. What is the substance of a comet, and what would happen if a comet should strike the atmosphere of the earth "head on"? (p. 409.)



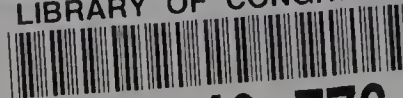
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